A STRATEGY FOR ENERGY EFFICIENT RESIDENTIAL LAND USE FOR THE CITY OF LETHBRIDGE

with funding provided by

Alberta
DEPARTMENT OF HOUSING
Innovative Housing Grants Program

A STRATEGY FOR ENERGY EFFICIENT RESIDENTIAL LAND USE FOR THE CITY OF LETHBRIDGE

September 1983

Prepared By:

DELCAN, DELEUW CATHER, WESTERN LTD.
FOR
THE CITY OF LETHBRIDGE

The views and conclusions expressed and the recommendations made in this report are entirely those of the authors and should not be construed as expressing the opinions of the Alberta Department of Housing.

With funding jointly provided by
Alberta Department of Housing
and
The City of Lethbridge

ISBN 0-88654-024-0

Alberta
DEPARTMENT OF HOUSING

Innovative Housing Grants Program

A STRATEGY FOR ENERGY-EFFICIENT RESIDENTIAL LAND USE FOR THE CITY OF LETHBRIDGE

DelCan Consulting Engineers and Planners
Enercon Consultants

INTRODUCTION:

This study was undertaken to produce an energy conservation strategy for the City of Lethbridge, with a focus on residential land use. The report is aimed at setting out those energy-efficient planning and house design guidelines that could have application in the City of Lethbridge and its planning and development process. Many of these guidelines could, however, have application in other communities.

The proposed strategy for Lethbridge is based on a demand or conservation approach to energy-efficiency which stresses:

1. Reducing energy consumption through measures aimed at improving transportation and land use efficiency; and
2. Reducing energy consumption in buildings; particularly residential structures.

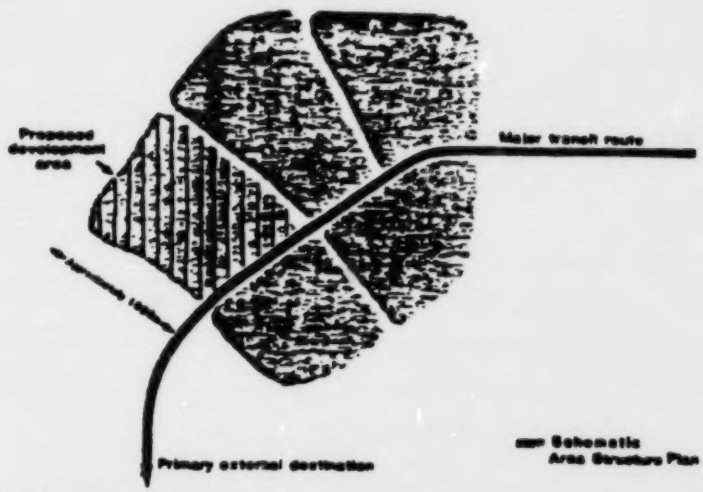


Figure 1: Public transit objectives combined with neighbourhood design objectives can provide an energy-efficient urban structure which incorporates essential neighbourhood activities and a range of population densities.

Copies of this report are available from Alberta Department of Housing, Innovative Housing Grants Program, 4th Floor, 10050 - 112 Street, Edmonton, Alberta T5K 2J1 (403/427-8150). Please refer to the order number shown in box at right, when requesting copies of completed reports.

Order No.: 8203261
IIA/I
Completed: Sept 1983
ISBN: 0-88654-025-9
Report: 235 Pages

METHODOLOGY:

The study included a comprehensive review of existing City planning documents and surveys of residents and of individuals involved in the housing industry. The findings of other studies related to energy-efficiency were also reviewed. The aim was to obtain opinions, attitudes and base data regarding potential energy conservation in housing and transportation. Several energy conservation strategies were reviewed and assessed for their potential energy savings and ease of implementation. The objective was to produce a set of planning and house design guidelines, tailored to the unique characteristics of Lethbridge, that would encourage energy-efficient residential development.

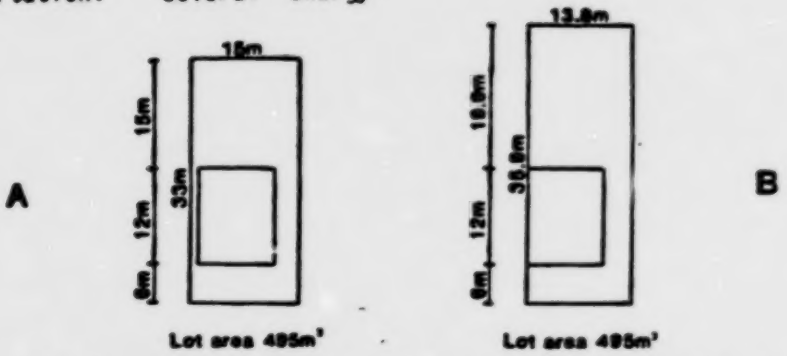


Figure 2: Lotting Arrangements. A slightly narrower but deeper lot (B) reduces the ratio of roads to lots, increases density and can with a zero side yard layout provide more usable yard space.

CONCLUSIONS:

The main conclusion of the study was that the City should adopt a "go slow" approach to energy conservation, rather than an approach that relies heavily on by-laws and other forms of regulation. Guidelines, incentives, and public education, supported by policies in statutory planning documents such as the General Municipal Plan, Area Structure and Area Redevelopment Plans, would be introduced to increase public awareness of energy conservation and encourage more efficient land use and transportation planning. Such guidelines would, for example, emphasize more land efficient lotting arrangements and measures to encourage increased public transit usage in the community and would be applied by the City in all of its subdivision design and review. Another important component of this strategy would be the education and involvement of the public in the construction of energy-efficient housing. A City-sponsored Home Show and Demonstration Project, planned for the spring of 1984, will see several local builders constructing to the energy efficient standards established for the "Lethbridge Model" Home. These standards detail those features which should be incorporated in new home construction in order to achieve energy-efficiency and are tailored to Lethbridge's climate and energy needs. A cost-benefit approach to energy-efficiency, which balanced the incremental costs of energy-efficient construction measures with potential energy savings, was used to derive the standards for the "Lethbridge Model" Home.

LETHBRIDGE MODEL HOME
ENERGY CONSERVTION FEATURES

	Insulation Level
Ceiling	RSI 6 (R35)
Wall	RSI 4.9 (R28)
Basement	RSI 3.5 (R20)
Foundation Perimeter	RSI 1.3 (R8)

Other features include:

- air tightness
- double glazing
- mechanical ventilation
- heat exchanger

FOREWORD

This study was made possible with funding provided by the Innovative Housing Grants Program of the Alberta Department of Housing. Originally conceived in 1978, the Program is intended to encourage, sponsor, and assist research and development in the fields of housing, site and subdivision design, energy conservation, site servicing and urban development. Generally, the aims of research funded by the Innovative Housing Grants Program are to reduce housing costs, increase the supply of appropriate housing or improve the utility or performance of dwelling units or subdivisions.

The main purpose of funding these studies is to examine the current issues in the field of housing and to develop innovations which offer improvements. Comments and suggestions regarding the information contained in these reports are welcome.

Innovative ideas come from a wide variety of applicants such as builders, developers, consulting firms, industry associations, municipal governments, educational institutions, non-profit groups and individuals. As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied.

Where possible the Department encourages the dissemination of study results under a standard cover and in a uniform format. This study, A Strategy For Energy Efficient Residential Land Use For the City of Lethbridge, was completed in April 1983 and subsequently released under a different cover.

Please send comments and suggestions or requests for further information to:

Innovative Housing Grants Program
Fourth Floor
10050 - 112 Street
Edmonton, Alberta
T5K 2J1

Alberta Department of Housing
September 1983

April 15, 1983

City of Lethbridge
Planning Department
910 - 4th Avenue South
LETHBRIDGE, Alberta
T1J 0P6

Attention: Ms. Helen Henderson

We are pleased to present ten (10) copies of the final report of **A Strategy For Energy Efficient Residential Land-Use** in Lethbridge.

The document is directed specifically at those conservation measures which we believe will have the most benefit for the City of Lethbridge. The report consists of three main sections. The first section outlines the study background and approach as well as providing some base information and a summary of findings from our Report of Preliminary Findings, October, 1982.

The second section deals with the Planning and Design Guidelines. Emphasis is placed on the policies and guidelines which could be incorporated into the current statutory planning documents, used by the City. Detailed information on neighbourhood, subdivision and site planning design factors related to energy conservation are established.

The third section provides information on the housing construction techniques which will provide the maximum benefit-cost from an energy conservation point of view. The associated computer analysis has helped to identify the best conservation measures in relation to the Lethbridge climate and energy costs. The design details provided will be particulary useful to house builders and individuals who are considering purchasing an energy efficient dwellings.

The Consultant would like to thank the review committee members and other City staff who have provided information and input into the study. In particular we would like to thank Helen Henderson for coordinating the meetings and providing liaison with other City Departments.

Yours sincerely,

Ralf Southwell, M.C.I.P.
Manager, Planning

RS/jeh

TABLE OF CONTENTS

			Page
1.0	STUDY BACKGROUND		1-1
	1.1	General Approach	1-1
		1.1.1 Scope	1-1
		1.1.2 Purpose	1-2
		1.1.3 Methodology	1-2
		1.1.4 Strategy Considerations for Lethbridge	1-3
	1.2	Community Profile	1-5
		1.2.1 Lethbridge Residential Dwelling Construction Activity	1-6
		1.2.2 Lethbridge Residential Energy Consumption & Energy Cost	1-6
		1.2.3 Lethbridge Climate	1-7
	1.3	Community Structure	1-8
2.0	PLANNING AND DESIGN GUIDELINES		2-1
	2.1	Findings	2-1
		2.1.1 Internal Document Review	2-1
		2.1.2 External Document Review	2-2
		2.1.3 Comparing Conservation Measures	2-3
		2.1.4 Conclusions	2-4
	2.2	Detailed Discussion	2-5
		2.2.1 The Alberta Planning Act	2-5
		2.2.2 The Oldman River Regional Plan	2-6
		2.2.3 The City of Lethbridge General Municipal Plan	2-7
		2.2.4 Area Structure & Area Redevelopment Plans	2-12
	2.3	Neighbourhood & Subdivision Design For Energy Efficiency	2-13
		2.3.1 Introduction	2-14
		2.3.2 Transportation & Land Use Planning	2-15
		2.3.3 Neighbourhood Planning to Facilitate Public Transit	2-16
		2.3.4 Factors Related to Increased Transit Usage	2-26
		2.3.5 Residential Streets	2-27

TABLE OF CONTENTS (Continued)

		Page
2.4	Subdivision Servicing	2-39
2.4.1	Roadways	2-40
2.4.2	Street Lighting	2-42
2.4.3	Shallow Utilities	2-42
2.4.4	Waterworks	2-43
2.4.5	Sanitary Sewer	2-44
2.4.6	Storm Drainage	2-45
2.5	Site Planning Guidelines	2-47
2.5.1	Solar Access and Orientation	2-47
2.5.2	Design Guildeines	2-48
2.5.3	Land Use By-Law Guidelines	2-53
2.5.4	Zoning	2-55
3.0	GUIDELINES FOR HOUSING CONSTRUCTION	3-1
3.1	Energy Conserving Residential Structures For The City of Lethbridge - An Analysis	3-1
3.1.1	Background	3-1
3.1.2	Methodology	3-2
3.1.3	Conclusion	3-14
3.2	Guidelines For The Construction of Energy Conserving Housing In Lethbridge	3-16
3.2.1	Design and Planning	3-16
3.2.2	Guideline Summary	3-16
3.2.3	Principles of Low Energy Residential Construction Reducing Energy Demand	3-41

APPENDIX LIST

A1 Skyspace and Shadow Data
A2 Public Survey Results
A3 Implications of Energy Retrofit on Municipal Bylaws

B1 Hotcan Computer Runs
B2 Environmental Data
B3 Energy Costs and Projections
B4 Lethbridge Contractor Survey

LIST OF TABLES

Table		Page
1.2	Lethbridge Population	1-5
2.1	26 Planning Measures For Energy Conservation	2-10
3.1	Housing Conservation Strategies Applied To The Model House & Incremental Costs Beyond the Alberta Building Code Standards	3-4
3.2	Benefit-Cost Analysis Summary	3-10
3.3	Allowed Air Infiltraton of Exterior Openings	3-17

SUMMARY

SUMMARY

In order to implement energy conservation strategies in the City of Lethbridge, a firm political committment towards this long term goal is necessary. The City government must provide the leadership and motivation necessary to offset the current financial and institutional impediments to the introduction of energy conservation strategies and technologies. The implementation of energy conservation strategies will require clearly defined and publicized objectives and will only be accomplished over a long time period.

The City should create a position within its administration for an energy conservation coordinator. Ultimately, this individual should be responsible for developing and implementing conservation programs in all City departments. The initial task of the conservation coordinator should be the implementation of the guidelines established in this study.

Upon review of the study findings the following points are considered to form the basis for an energy conservation strategy for the City of Lethbridge.

1. Supply vs. Demand

   We believe Lethbridge should take a demand or conservation approach to energy efficiency rather than one oriented toward improving or increasing supply. Lethbridge can probably do very little about the supply situation but considerable savings can be made through appropriate conservation techniques.

2. The conservation approach should stress:

   a) reducing energy consumption, through planning measures related primarily to improving transportation and land use efficiency; and

   b) reducing energy consumption in buildings, primarily residential structures.

3. To achieve the above, emphasis should be placed on:

   a) planning neighbourhoods to encourage public transit usage and shorter trip distances;

   b) increasing the density of land-use by reducing the land area required for roads and by developing more efficient lotting patterns: and

   c) Improving the standards of construction in buildings to achieve "air tightness", and super insulation.

4. Less importance should be given to solar orientation and solar access than the above factors.

5. In attempting to achieve solar orientation and solar access, the City should seek solutions through the planning process; primarily through the review and approval functions for site plans and plans of subdivision. The City should avoid attempting to achieve solar orientation and solar access, through its comprehensive land use by-law.

6. The guidelines and recommendations set out in this document with regard to more efficient land use planning should be supported by policies in the City of Lethbridge General Municipal Plan and Area Structure/Redevelopment Plans.

7. Policies in the General Municipal Plan and Area Structure/Redevelopment Plans, focusing on community structure, transportation and housing construction should be given priority over less important policies of solar orientation and access.

8. The City should take a "go slow" approach based on examples such as its proposed Energy Demonstration Project, rather than passing by-laws or other regulations.

9. The City should make representations to the Province for improved building codes that would provide for air tightness, super insulation and other techniques in new construction to increase energy efficiency.

10. Incentives should be given to developers who build more energy efficient homes. The incentives which should be considered include:

    a) Priority lot selection (City lands) for builders who intend to build energy efficient homes.

    b) Additional lot subsidy on City lots for 1983-1984 and longer term subsidy programs for demonstration projects and innovative multi family developments.

    c) City aid to developers with regard to obtaining any available grant or subsidy programs for housing development. The City's

main function would be the dissemination of information on these programmes.

d) Priority timing for inspections and approvals for energy conservation developments.

e) City subsidized monitoring programs for builders who wish to monitor their energy efficient homes.

11. With respect to the implementation housing aspect of the study, the City should:

a) Print and distribute the "Guidelines for the Construction of Energy Conserving Housing" developed in this study. These guidelines should be distributed through the Building Department and the Information center outlined below. The guidelines should be distributed to all residential contractors and subtrades and to individuals interested in building new homes or adding additions to existing homes.

b) Create a conservation information center (initially concentrating on the housing sector) which distributes information on maintaining, retrofitting, upgrading and building new energy conserving structures. This information centre should be widely publicized to the general public. The energy conservation coordinator could provide this service from his/her office in the initial stages. A wide variety of information brochures are available from the Federal and Provincial governments and their agencies.

c) Organize workshops (perhaps in cooperation with HUDAC) for the local building industry. These workshops should first explain the guidelines for energy conservation developed for the City, and second, train contractors and subtrades in the procedures of building low energy structures.

d) Encourage the community college (or university if appropriate) to offer courses to the general public on home retrofit for conservation, and the building of new energy efficient structures.

e) Cultivate the local media's interest in conservation activities and achievements, and develop a media program for the continual dissemination of conservation activities and services.

f) Advise the building inspectors to implement a special inspection (prior to drywall application) to ensure that houses conform to the energy conserving guidelines.

g) Investigate a program (of at least one year duration) to provide a grant, subsidy, interest free loan, or land rebate to local residents or contractors who build to the guideline standards. This subsidy should be at least $3,000.00, in order to substantially offset the $4,000.00 incremental cost necessary to build a low energy home.

h) Encourage or invite the establishment of local energy conservation businesses such as: Home energy retrofit and air tightening services, energy conservation design and planning, retail energy conservation products and services.

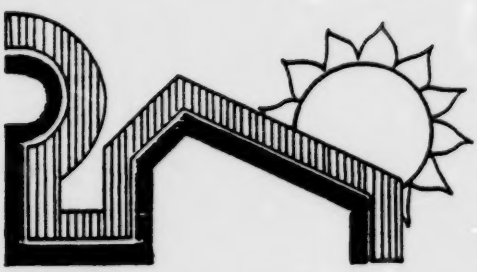
LETHBRIDGE MODEL HOME
ENERGY CONSERVATION FEATURES *

	Insulation Level
Ceiling	RSI 6 (R35)
Wall	RSI 4.9 (R28)
Basement	RSI 3.5 (R20)
Foundation Perimeter	RSI 1.3 (R8)

Other features include:

- air tightness
- double glazing
- mechanical ventilation
- heat exchanger

* Detailed discussion of the Lethbridge Model Home is included in Section 3.



1.0 Study Background

1.0 STUDY BACKGROUND

1.1 General Approach

1.1.1 Scope

This report was jointly funded by the Innovative Housing Grants Program of the Alberta Department of Housing and the City of Lethbridge. The views and conclusions expressed, and the recommendations made, in the report are entirely those of the author and should not be construed as expressing the opinions of the Alberta Department of Housing.

This report is not intended to serve as the definitive work on energy conservation as related to land use planning and energy conservation techniques for the home. However, the field has been covered thoroughly.

The scope is limited to setting out those planning and housing design guidelines that could have application in Lethbridge. As such these guidelines focus on those policies, programmes and techniques that might be employed through the planning and development process in Lethbridge. Unlike most of the material written on the subject the relative importance of these guidelines, in contrast to other methods to improve energy efficiency, have been addressed in this report. The report also covers findings with regard to existing policies and programmes aimed at energy conservation through land use planning procedures in Lethbridge.

It is outside the scope of this report to deal fully with the transportation component of energy consumption. However, the results of the public survey, conducted as part of the study, revealed that gasoline costs for operating a car for work and other private runnings are equal to the combined natural gas and electricity cost for many homes. In view of this high energy consumption related to private car usage, emphasis has been placed on planning more efficient neighbourhood and subdivision layouts to encourage public transit, reduce trip lengths and avoid excessive land area for roads and lanes.

1.1.2 Purpose

The primary purpose of this report is based on the following four points:

a) To provide the City of Lethbridge with an appropriate framework to develop a "strategy" regarding energy efficiency and conservation.

b) To set out planning and design guidelines directed at conserving energy in Lethbridge along with relevant recommendations on the subject to the City.

c) To provide the City of Lethbridge with sufficient information on the "state of art" as it pertains to housing technology for energy conservation.

d) To ensure that the guidelines are meaningful in conserving energy and not merely an end unto themselves.

1.1.3 Methodology

Because the study has been undertaken with considerable interaction between experts in energy conservation, land use planning, housing construction, urban design and development engineering we believe the report is "well-balanced". A definite lack of balance exists in the great majority of material that was reviewed for the study.

The methodology focused on a comprehensive review of the present situation in Lethbridge including surveys of residents and individuals involved in the housing industry. The findings of other studies have also been used where appropriate. These findings were compared throughout the

study period with the study teams own results thus permitting verification and "fine tuning" of the findings.

Following the study background, the report is divided into two main sections. Section 2 deals with the land use planning and design guidelines recommended for Lethbridge. Section 3 provides a comprehensive set of guidelines for energy conserving housing construction considered to produce the maximum benefit-cost ratio for Lethbridge.

Both sections are equally important and can, if implemented, together provide major reductions in energy consumption in residential areas over the long-term.

1.1.4 Strategy Considerations For Lethbridge

What kind of an Energy Strategy is applicable to Lethbridge? Three categories of Strategies applicable to conservation in general have been identified by Olsen and Goodnight (1977).

a) Strategies that attempt to change peoples' minds, usually through information and education.

b) Strategies that attempt to change peoples' actions, primarily through incentives and constraints (the carrot and the stick).

c) Strategies that attempt to change the various contexts (legislative, developmental, cultural, etc.) within which people act.

It is likely that Lethbridge will have to employ a mixture of the above strategies. In selecting a strategy approach it is particularly important to ensure that the measures adopted are mutually reinforcing. It makes little

sense, for example, to opt for energy conserving techniques such as solar orientation for dwelling units in a subdivision that will require development costs far exceeding the long term energy savings, yet this has been done in many municipalities. It is important to link energy proposals to other local concerns. One example cited in Planning Land to Conserve Energy is in an area of high unemployment to use energy conservation programs to create jobs retrofitting, improving insulation, etc. Toronto and Vancouver have embarked on such programs and it would seem to have application in a number of locations across Canada including Lethbridge.

Common sense will also have to prevail in dealing with energy issues, to ensure energy proposals are mutually reinforcing. Imposing energy controls that have a negative impact on the environment, violate architectural design standards, impinge unecessarily on private property rights or conflict with other community goals or objectives are not likely warranted. Again this has occurred in some communities.

The first step in defining any strategy or course of action is to define the problem as it pertains to Lethbridge. Does Lethbridge have an energy problem? Certainly the City does not have a critical energy supply problem and in terms of fuel costs has about the lowest natural gas and gasoline cost in the Country. However, in the future the City will be affected by substantial increases in the cost of oil and gas and will share the same uncertainty as other communities in not knowing what the long-term energy supply situation may be.

Here we must assume that Lethbridge is committed to doing something about the problem and it is logical that they direct their efforts to conservation. Lethbridge can probably do little about the supply side of the energy problem, however, it does share opportunities to deal with the demand aspect.

In this regard energy conservation is defined as any or all of the following:

a) Reducing the amount of energy consumed, including both direct and indirect consumption (the latter, referred to as embodied or imbedded energy, is expended to produce the given commodity or service)

b) Increasing the efficiency of energy use (whether measured by the First or Second Law of Thermodynamics) and

c) Substituting non-critical (widely available) for critical (subject to shortages) forms of energy and renewable for non-renewable forms.

1.2 Community Profile

Lethbridge is located in the heart of major agricultural, oil, gas and coal resources. The City encompasses a large geographical trading area. The City has grown substantially over the past two decades and expects continued high growth due to the activity foreseen in these resource sectors.

TABLE 1.2

LETHBRIDGE POPULATION*

YEAR	POPULATION	PERCENTAGE CHANGE EACH DECADE
1961	35,454	-
1971	41,217	13.9%
1981	54,072	31.2%

* From statistics Canada Census Information

1.2.1 Lethbridge Residential Dwelling Construction Activity*

Number of dwelling units in 1981	19,745
Number of units constructed since 1961	9,470
Number of renovations or additions since 1961	8,700

	Decade 1962-1971	Decade 1972-1981
Average new single family housing starts per year	201	434
Average new duplex and apartment starts per year	28	74
Average renovations or additions per year	354	516

* From building permit office - City of Lethbridge

1.2.2 Lethbridge Residential Energy Consumption and Energy Cost

The energy source for residential space heating and domestic hot water is almost exclusively natural gas in the City of Lethbridge. The current (1982) average residential natural gas consumption rate is 184 gigajoules per year. Average natural gas consumption has decreased by approximately 10% during the past decade.

Electricity consumption for lights and appliances has increased by approximately 20% during the past decade to a current average consumption of 6240 KWH per year per household.

The average cost of residential energy for selected years and the projected costs based on current consumption figures and dollar values, are listed in the following table.

TABLE 1.2.2

YEAR	NATURAL GAS	ELECTRICITY	TOTAL	PERCENTAGE INCREASE FROM 1977
1977	$ 204.61	$156.26	$ 360.87	-
1982	717.56	246.24	963.80	167%
1986	861.12	430.56	1,291.68	258
1990	1,144.48	541.63	1,686.11	367
2001	3,150.08	923.52	4,073.60	1029

Note Cost projections are based on the "National Energy Program Update 82 Supply/Demand Outlook, 1981-2000".

1.2.3 Lethbridge Climate

Lethbridge has a relatively mild climate compared to most Western Canadian Prairie cities. The region received more hours of bright sunshine per year than any other area of Canada.

Latitude: 49°38' North
Longitude: 112°48' West

Design Temperature[1]: -31° Celsius
Yearly Mean Temperature: 5.3° Celsius
Heating Degree Days[2]: 4718 Celsius Degree Days

1 Ninety-nine percent (99%) of the time the average temperature is warmer than the design temperature: heating systems are typically designed to the design temperature.

2 The number of degree days per day is defined as the difference between average outdoor temperature and a room temperature of 18°C. "Degree days per year is the sum of the average degree days per day.

Wind Speed:	20.4 km/hour average 16.8 km/hour low average - August 23.1 km/hour high - December
Hours Bright Sunshine:	2387 hours per year
Sun Path:	The following table describes the suns' position at each solstice and equinox date.

Time of Year	Altitude (Degrees above horizon at solar noon)	Azimuth (Sunrise/Sunset direction, degrees east or west of south)
December 21	17°	50°
March 21/Sept. 21	42°	90°
June 21	64°	126°

1.3 Community Structure

The pattern of urban development has a definite effect on energy consumption. In studies conducted to test the relationship between urban form and energy use, it has been cleary shown that low density "sprawl" is the highest energy consumer while higher density compact centres are the most efficient. Transportation costs are the main reason for the savings.

Shorter trips and the opportunity for an efficient transit system and more walking trips are the important elements in reducing transportation costs. The Metropolitan Toronto Transportation Energy Study determined that energy savings of up to 10 percent may be possible through land-use changes. If this is combined with a 10 percent increase in car occupancy rates and a similar increase in transit usage a further 15 to 17 percent improvement could be obtained. For cities up to a population of 200,000, the centralized structure is efficient. Perhaps the "mill town" provided one of the most energy efficient examples. Centralized employment, with housing grouped around the core, required minimal movement of people, goods and services. This is not suggesting we plan our communities following the "mill town" concept. However, certain principles regarding places of employment, shopping, and institutional locations and the distribution of housing must be followed if energy efficiency is to be achieved. This distribution is important both on a City wide basis and at the neighbourhood level.

The present structure of Lethbridge conforms to the centralized model with the exception of West Lethbridge. If the same facilities which presently exist in West Lethbridge had been developed closer to the City core or at least on the east side of the River, trip distances and transportation energy consumption would have been reduced. The idea of an efficient corridor development is not possible due to the lack of developable land in the River valley.

Two possibilities exist to improve the long term City structure.

a) Stop further long term development in West Lethbridge and concentrate all uses on the east side of the River.

b) Encourage more development in West Lethbridge to a level where an efficient public transit system can operate and trips are balanced during both the morning and evening peak periods.

In view of the present commitments to development in West Lethbridge the second possibility appears to be the only logical choice. However, considerably more study will have to be done to determine the energy implications in the long-term. The costs will undoubtedly be higher particularly when new roadways and bridges are required accross the valley. Other factors to be considered include:

a) Pressures for a major shopping centre in West Lethbridge and the effect on the existing Downtown;

b) The effect of a major employment centre in West Lethbridge on traffic patterns; and

c) The overall pattern of major trip generators i.e. employment centres, shopping centres, educational establishments etc. in relation to the main road system and viability for public transit operation.

In East Lethbridge the development pattern is reasonably energy efficient with a centralized business centre and shopping area surrounded by residential development. Industrial development is well situated in relation to rail facilities and prevailing winds and does not require extensive trip lengths from the majority of residential areas.

Another concern is one pertinent to "strip" commercial development. Area Structure Plans as well as the General Municipal Plan should be more restrictive with respect to the location of commercial facilties outside the central core. Local retail outlets are necessary but again on a centralized

basis relative to the existing and planned residential areas they are intended to serve.

Additional medium and high density redevelopment in the central core of the City would also contribute to energy conservation. Current redevelopment plans are already addressing this point and it is hoped that further policies can be directed towards an efficient City centre with a mix of commercial and residential uses. It is interesting to note that only 32% of the respondents in the telephone survey wanted to see more housing closer to the City Centre, 48% did not. It is felt however that sufficient demand exists to consider additional housing projects particularly in the railway redevelopment area.

In conclusion, we wish to emphasize the importance of the urban structure in energy conservation. All major decisions in terms of land-use and particularly major activity generators should be considered with energy conservation in mind. Sprawl must be avoided and a logical pattern of uses developed which minimizes travel distances and supports public transit usage. The General Municipal Plan must address these principles in more detail. More is written on this topic in the following sections.

REFERENCES

1. Planning Land to Conserve Energy - Environment Canada Land Directorate - Land Use in Canada Service Ag 25, Page 196.

2. Metropolitan Toronto, - Transportation Energy Study Background Report 1 - Land Use, Transportation and Energy Relationships.

2.0 Planning & Design Guidelines

2.0 PLANNING AND DESIGN GUIDELINES

2.1 Findings

The initial data collection and survey interviews were conducted under Phase 1 of the study. A summary of findings as they relate to existing policies and statutory documents is given below.

2.1.1 Internal Document Review

From a land use planning perspective few policies or procedures existed that would enhance energy efficiency in the community. Perhaps the most significant finding was the lack of planning, design and development guidelines at the Area Structure Plan and Subdivision approval stages. It is in these two areas, that we believe lie the greatest opportunities to positively effect energy conservation through the planning process.

Likewise certain broad policies can be incorporated in the General Municipal Plan that could improve energy efficiency in Lethbridge or at least add strength to the more detailed policies in Area Structure and Redevelopment Plans.

We have serious reservations about the appropriateness of using the Land Use By-law in an attempt to regulate energy efficiency, especially in existing "built-up" areas. Those areas normally dealt with under a by-law include solar orientation and solar access factors that we believe can best be handled through the planning process in developing areas. The arbitrary nature of the by-law, and the complications which arise in attempting to administer solar orientation and access in existing developed areas, have caused some serious problems in a number of Canadian cities.

It was felt that a lenient approach should be taken to those waiver applications where solar access requirements might encroach on yard setbacks or exceed height limits. This approach would be best framed in general policy dealing with the issue in the Land Use Bylaw.

2.1.2 External Document Review

Our most signficant finding here has already been mentioned. Again, it is the fact that little has been written showing the relative importance of house orientation in conserving energy in contrast to other measures such as improved construction technique. From the literature available, the reader could easily come to one of two conclusions:

a) That through certain urban planning techniques (particularly proper solar orientation and protecting solar access) the urban planner can have a significant impact on improving energy efficiency and thereby reducing energy costs; or

b) That these land use planning techniques are all that is required to achieve energy efficiency.

We believe because of this situation some communities have or are using techniques in the subdivision and site planning approval process and in zoning by-laws with negative results. Some developer resistance has been encountered because of the application of certain techniques that have been extremely expensive for little or no gain in energy savings. It is interesting to note that the Federal Ministry of Energy, Mines and Resources, is attempting to place the land use planning techniques into proper perspective along with other means of conserving energy.

Another finding of our external research is that the same things have been written about energy conservation and urban planning over and over again. Rarely are some of the techniques questioned with respect to effectiveness. It is not that certain techniques do not have application, the question is how, when, and where they are applied.

2.1.3 Comparing Conservation Measures

As mentioned earlier, little has been written regarding the relative importance of planning measures in contrast to other areas of energy conservation. It is important to stress that the measures that can be taken through urban planning to reduce the energy requirements of a structure are quite small compared to other measures. On the other hand land use planning can have a significant impact on transportation energy requirements.

In many communities urban planning measures have focused on solar orientation and solar access. However, in a standard house the amount of energy saved through proper orientation and free access to the sun is only about 6% or currently about $50 per year. In contrast good insulation and air-tightness can give a 60% to 65% improvement in energy consumption. In a well insulated and air tight home the sun may provide up to 25% of the home heating requirements but the energy required to heat the house in the first place is so low that again the cost savings may only amount to a few dollars per year. Solar orientation for active systems still has not proved to be cost efficient with the possible exception of hot water heating systems and low cost do it yourself projects.

In spite of the relatively small gains resulting from a proper orientation it is still desirable to plan proper orientation into a subdivision provided the design does not suffer from an amenity point of view or that the subdivision

is less efficient from a land use and transportation point of view. If a lower density results, or the percentage of land area for roads increases because of solar orientation, the net result may be a less efficient higher energy consuming subdivision.

The primary rule here is that if all other factors are equal try to achieve good orientation on the maximum number of units.

In the long term high fuel costs may make even small savings from solar orientation important.

2.1.4 Conclusions

Based on the study findings the following points are considered to be important and should form the basis for the "energy strategy".

a) The City should concentrate on achieving energy efficiency in home heating by seeking to have new construction employ the necessary techniques for super insulation and air-tightness.

b) The City should also seek to have as many existing homes as possible retrofitted on a similar basis.

c) In order to best achieve the above, a concentrated effort by the City to educate the public in the benefits of proper insulation and air-tightness should be launched.

d) The City should develop appropriate policies in its General Municipal Plan and Area Structure/Redevelopment Plans which will:

i) Produce an efficient City land use pattern to minimize trip distances and maximize public transit usage; and

ii) set out design guidelines for more efficient subdivision designs.

e) The City should encourage solar orientation of houses only if it does not reduce the efficiency of the design from a transportation or density point of view.

f) The City should avoid trying to regulate solar orientation and access through its land use by-laws for either new or existing areas within the City.

2.2 Detailed Discussion

In our review process, which culminated in a Report of Findings we covered the Alberta Planning Act, the Joint General Municipal Plan, City of Lethbridge General Municipal Plan, Various Area Structure and Redevelopment Plans, Subdivision and Site Plan Approval Policy, the comprehensive land use by-law and city waiver procedures.

We will cover those documents here more specifically as it pertains to planning and design guidelines.

2.2.1 The Alberta Planning Act

Although it is recognized as being beyond the scope of the study mandate and outside the direct control of the City, we do not believe the Act should be amended in any way to deal specifically with energy conservation through land use planning. Our concern would be that such a specific amendment would only focus more attention on the subject than is warranted, and that

such attention could spark a lot of misdirected or misguided effort on the part of overzealous municipal and/or Regional Planning Commissions. From our review of the Act, we believe sufficient authority already exists for municipalities to cover energy conservation through planning. It appears that municipalities could provide a full range of policies through the General Municipal Plan process to promote, encourage or even require energy efficient planning. Likewise the authority exists to provide policies and guidelines in Area Structure and Redevelopment Plans, again encouraging or requiring energy efficient planning. In our opinion the Act should at this time remain silent on specific mention of energy conservation through land use planning. However, it may be appropriate to consider amendments to reduce the maximim land which can be used for roads and lanes from 30% to 25% or less. As discussed later, this would encourage more attention to efficiency and an overall improvement in density.

2.2.2 Joint General Muncipal Plans

The proposed Joint General Municipal Plan which was prepared by the Oldman River Regional Planning Commission does not deal directly with the question of energy conservation. However, the policies dealing with the protection of good agricultural land, the encouragement of compact urban growth and the discouragement of leap-frog development will generally support the principle of a more efficient urban structure.

It is felt that the Plan could be more specific with regard to an energy conservation approach to City expansion and the possible consolidation of rural uses, particularly industrial sites in the adjacent County lands. Consideration should also be given to identifying those areas outside the potential long term City growth areas which could be used to accommodate country residential development in a less dispersed form. If it is agreed that the demand for acreage development has to be accommodated it is more

energy efficient to locate them in a few selected areas with good access to the major road system. Every effort should be made to rationalize the rural transportation system particularly the school bus routing. A study should be conducted to see if some of the demand for small acreages could be accommodated in large lot subdivision in the smaller towns and villages. In many instances the people who purchase a 2 or 4 acre parcel in the country may be equally happy with a 1/4 or 1/3 acre lot in a small village.

2.2.3 The City of Lethbridge General Municipal Plan

Those guidelines having application here would be directed toward more general policy and should cover an energy strategy for Lethbridge. The strategy measures set out should be embodied in the General Municipal Plan. Policy guidelines should include:

a) Urban Structure policy should focus on the most efficient urban form suitable for Lethbridge. More work will have to be done on this topic to ensure that the transportation components are assessed fully. Basically however, the policy should strive to encourage a reasonably compact downtown with medium to high density commercial and residential development. As previously noted in Section 1, this must be done in the context of public demand and opinion. The public survey indicated some resistance to overly high densities in the City. Other employment and activity centres should be carefully located to avoid creating multiple destinations which cause transportation problems and do not support an efficient public transit system.

b) Density is a significant factor in reducing energy needs for heating, transportation and other services. The General Municipal Plan must encourage higher densities related to a compact structure model for the City. As previously noted in Section 1, this must be done in the

context of public demand and opinion. The public survey indicated some resistance to overly high densities in the City. Areas of increased density should relate to transit services, places of employment, shopping and institutions. The present Railway Relocation Downtown Phase II and London Road Area Redevelopment Plans do encourage higher density housing throughout the City. However, the political ramifications associated with higher densities are real and it will likely require a go-slow approach coupled with a public education program to bring about a redistribution of densities. Concentration should likely be focused over the next few years on low-rise multiple housing as opposed to high-rise apartment dwellings. More emphasis should be placed on incremental improvements in residential densities through innovative lotting patterns and reducing the land area required for roads and lanes . This point will be discussed in more detail later.

c) Mixed Land Uses are more energy efficient than segregated land uses. This seems counter to most planning policy and the provisions of zoning which are generally rooted in separating uses and seeking compatibility. Some areas where mixing land uses might be encouraged include, permitting small businesses to operate out of the home and permitting commercial uses (office and retail) in structures containing dwelling units especially in the downtown area. This is already being done in the City to some extent.

d) Policy Guidelines - the following energy conserving measures, which relate to residential development and in some cases to the overall City structure, have been adopted from a publication by Energy Mines and Resources entitled Energy and Urban Planning. The measures are based on five main objectives:

i) to produce a more compact and contiguous urban form;

ii) to plan land uses to minimize vehicle trips;

iii) to design more efficient neighbourhoods and subdivisions;

iv) to improve site planning techniques for improved efficiency; and

v) to orientate the appropriate development controls, standards and education programs towards energy conservation.

The following table sets out the conservation measures in relation to the above objectives.

TABLE 2.1

26 PLANNING MEASURES FOR ENERGY CONSERVATION

Objective	Measure
A. More compact and contiguous	1. Increase overall densities in municipal plans
	2. Encourage infilling and redevelopment
	3. Minimize urban sprawl
	4. Encourage large-scale integrated development
	5. Consider energy implications of major urban infrastructure
B. Land use to minimize vehicle trips	6. Locate interrelated land uses in close proximity
	7. Concentrate development in nodes and along transit corridors
	8. Encourage greater mix and integration of uses
	9. Discourage isolated commercial development
	10. Increase local recreational opportunities
C. Energy-efficient neighbourhoods	11. Design local street systems to minimize energy used for transportation
	12. Align streets for optimum solar gain
	13. Encourage cluster development
	14. Provide more neighbourhood services and facilities
	15. Provide for district heating and waste heat recovery
	16. Encourage multi-unit structures
	17. Introduce energy conservation measures into neighbourhood rehabilitation planning

TABLE 2.1 (continued)

Objective	Measure
D. Site planning for greater thermal efficiency	18. Promote energy-efficient building design 19. Orient lots and buildings to profit from natural features 20. Encourage landscaping for conservation 21. Protect solar access
E. Energy-oriented develeopment controls, standards and regulations	22. Remove barriers to energy conservation in existing development controls 23. Provide for energy conservation in development regulations and review processes 24. Issue voluntary guidelines for energy-efficient development 25. Provide incentives to developers 26. Encourage energy impact assessments 27. Initiate educational programs in energy conservation techniques for the general public and the development and building industry.

It is recommended that these objectives and conservation measures be incorporated into the General Municipal Plan.

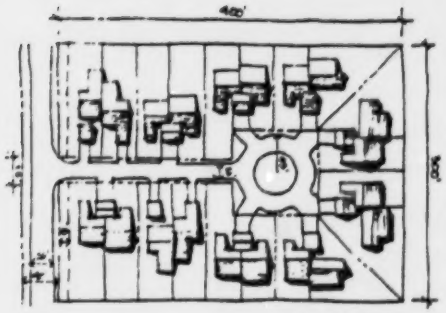
2.2.4 Area Structure and Area Redevelopment Plans

The policies and conservation guidelines which should be incorporated into these documents would be similar to those set out under the General Municipal Plan. However, they would be more site or location specific and the plan would indicate visually how the measures should be implemented.

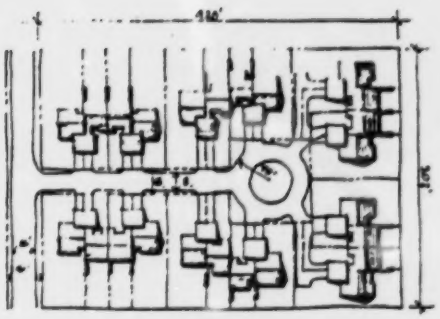
It is important that a review of the Area Structure and Area Redevelopment Plans be made to determine consistency with the measures set out under the previous sub-section. A preliminary review carried out as part of this study has shown that many of the current plans are not consistent with the recommended urban structure model. They are generally not based on compactness, they do not really encourage higher densities, mixed uses or public transit usage. Policies to encourage proper orientation of lots and structures exist but not in all areas.

Some specific recommendations for incorporation of ASPs and ARPs are set out below.

a) Encourage comprehensively planned developments in new and redevelopment areas. Compared with the traditional large lot subdivision a good planned unit development can be up to 50% more efficient in land and energy use.



7.25 Duplex
Net Density



8.25 Quadplex
Net Density

SOURCE: Cost Effective Site Planning,
The National Association of Home Builders.

b) Incorporate the neighbourhood and subdivision planning guidelines set out in the following sub-section.

c) Familiarize the development industry and local builders in the City with the planning and development principles which should be followed.

d) Work with land owners and developers in preparing a new area structure plan so that a common understanding and cooperation on basic objectives can be reached. In most cases the developer will have much to gain through incorporating the energy conservation techniques.

2.3 Neighbourhood & Subdivision Design For Energy Efficiency

The aim of this sub-section is to study the specific measures which could be implemented to make future neighbourhood and subdivision developments more energy efficient.

2.3.1 Introduction

The City has considerable control at the Area Structure Plan stage and at the subdivision approval stage to require that certain guidelines are followed in order to meet the requirements of the "Energy Strategy". However, it is fully realized that the policy and guidelines adopted must be realistic in their requirements. It is not the intent to recommend radical departures from present practices but it is possible to make considerable efficiency gains by adjusting land use patterns, making better use of the land and by reducing travel distances between the home and major employment and shopping areas.

The strategy for improved efficiency through better planning, is by its nature, a long range program. However, by implementing the program now, the City of Lethbridge will be better equipped to avoid many of the problems facing larger cities. As new areas are developed and older areas redeveloped energy saving design features can be built in which will benefit the community as a whole over future years.

Many energy studies have advocated increased density as a major factor in conserving energy. While this general principle is supported, it may not be realistic in the City of Lethbridge in the short term if this means smaller lots and more multi-family developments. It became clear from the public survey that there may be a definite limit to the proportion of smaller lots and multi-family homes which can be marketed in a relatively small, rural based city such as Lethbridge. As a result, the approach taken is one of trying to achieve increased efficiency in the design of residential areas through better planning. For example, the design of neighbourhoods to facilitate public transportation will, as shown later, provide a number of community benefits. Similarly careful attention to details at the subdivision design stage will help reduce the land area required for roads and lanes, and

effectively increase housing density without necessarily having to reduce average lot sizes. Based on the survey results and supporting actual cost averages, it is clear that in many households gasoline costs for the operation of a private car are equal to the combined costs for natural gas and electricity. Therefore, the strategy adopted should include both design guidelines for improvements in transportation efficiency as well as energy conservation in the home. The possible improvements in the housing technology are dealt with in Section 3. The strategy for transportation and land use planning is discussed below.

2.3.2 Transportation and Land Use Planning

In the City of Lethbridge, as in many cities, transportation planning, public transit planning and land use planning are dealt with as separate entities. This can unconsciously lead to lack of efficiency resulting in higher capital costs, maintenance costs, and an overall increase in energy consumption.

Energy conservation is perhaps the single most important link between all aspects of urban development. In most instances the objectives for energy conservation will be similar to the individual objectives which are important in planning land uses, roadways and public transit. From an urban development stand point the objective is to develop a transit orientated transportation and land use plan which will, in the long run, provide the citizens of Lethbridge with a real alternative to the private car. At the same time, the changes in land use and road system required to make a public transit system work effectively will also:

a) Provide a more cost effective road system;
b) Rationalize traffic patterns;
c) Encourage more efficient land use patterns;

d) Reduce dependence on automobiles;

e) Encourage more public transit, bicycle and walking trips.

It is firmly believed that if a strategy is adopted which meets the above objective, considerable energy savings can be achieved without loss of mobility, amenity or quality of life style. Again, it is important to stress that even if the move towards encouraging more people to use public transport is a long term goal, real gains can be made in the near future by adopting the land use and transportation principles which support a good public transit system.

2.3.3 Neighbourhood Planning To Facilitate Public Transit (Reference 1)

Unfortunately the provision of an attractive public transit service in the typical low density residential neighbourhood is severly restricted by the street layout and distribution of population density. The primary concern in the design of communities to accommodate public transit is the provision of transit at a high level of service.

The success of the bus service is a function of four interrelated items:

- Frequency of service
- Walking distance
- Travel time
- Community impact

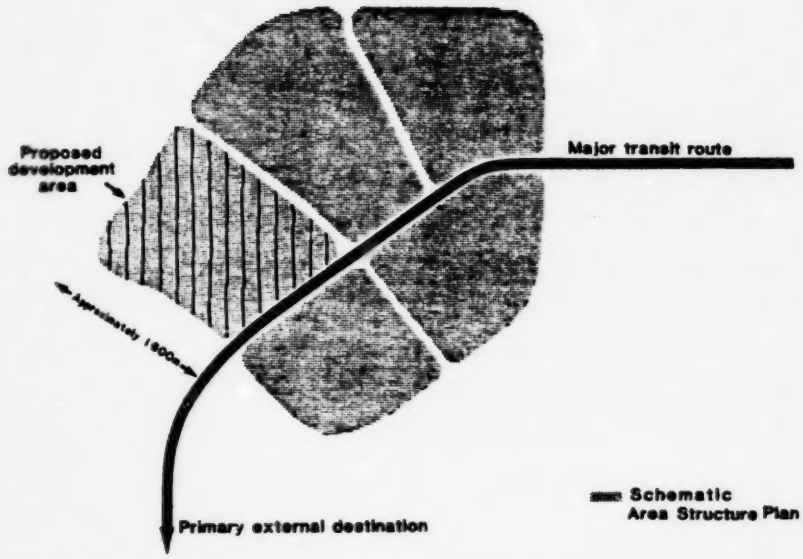
A community designed to accommodate transit should experience frequent service, walking distances to bus stops and transit travel time should be as short as possible and the transit routing through the community should have minimum impact on the quality of life in that community. A more detailed description of these items follows.

a) Frequency of Service

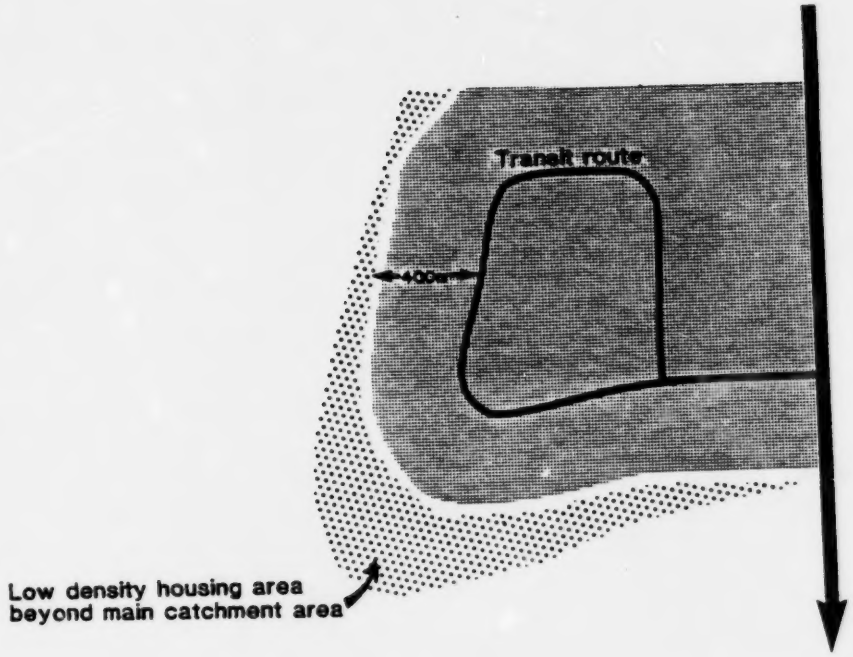
The frequency of service is dependent on the demand for the service. Therefore to make frequent service viable from the viewpoint of the transit authority the community has to be designed to maximize demand. This is accomplished by locating high density and high activity uses at focal points along the routes or potential routes on which transit will operate. Such uses include high density residential development, retail/commercial complexes, institutions, community recreation centres etc. It is important that these areas be located on or close to transit routes, however, it is desirable that these areas be concentrated at focal points along the route and not continuously along the route. This arrangement requires fewer bus stops thus minimizing the overall travel time.

The following design guidelines have been developed for input at the Area Structure Plan stage. The objective is to combine the transit objectives with neighbourhood design objectives to provide an efficient urban structure which incorporates essential neighbourhood activities and a range of population density. Naturally each neighbourhood will have its own characteristics influenced by topography, servicing, and drainage. These factors should be considered in parallel with the following design guidelines.

i) Plan neighbourhood size and shape in relation to the proposed major transit route. External destinations for transit and other vehicular traffic should be determined at the Area Structure stage.



ii) Based upon the proposed neighbourhood boundary, identify the primary catchment area for the transit service. A 400 m walking distance should be taken as the maximum. Areas beyond this should be served either by a second transit service or designed for lower density housing.

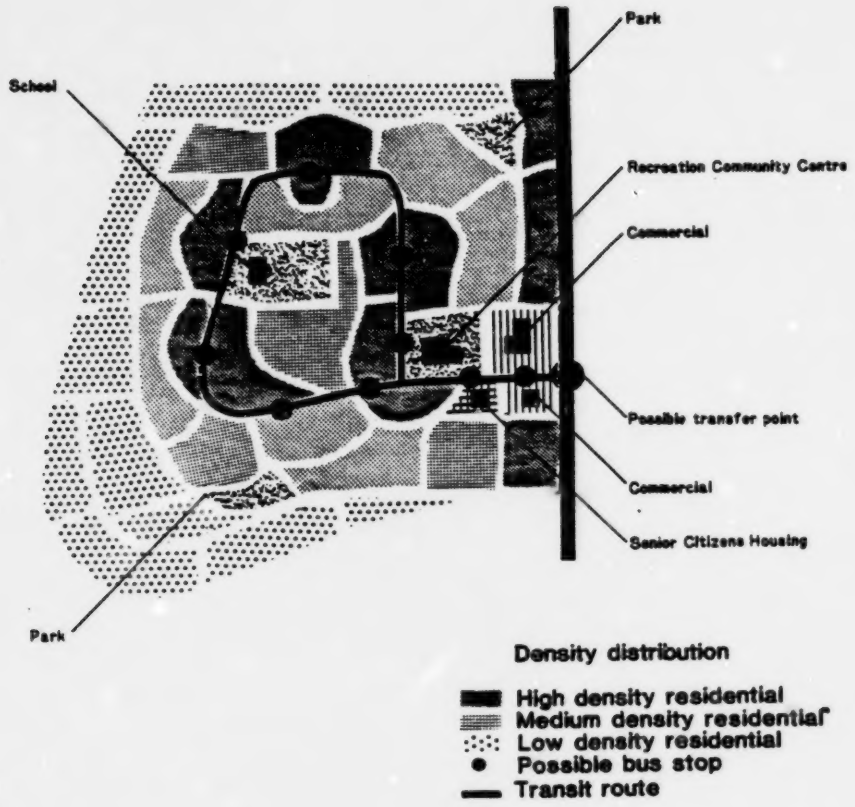


iii) Within the neighbourhood, the land use should be designed under the following guidelines.

- Ensure development on both sides of the bus route.

- Provide highest density and major activity points close to the bus route, particularly the bus stops and any transfer points. Development density should graduate outward from the bus route.

- Design street geometry to give priority to the bus route.



iv) Identify the approximate location and spacing of the bus stops at the Area Structure Plan stage. These can then be coordinated with the design and spacing of collector and local streets at the subdivision design stage.

b) Walking Distance and Street Layout

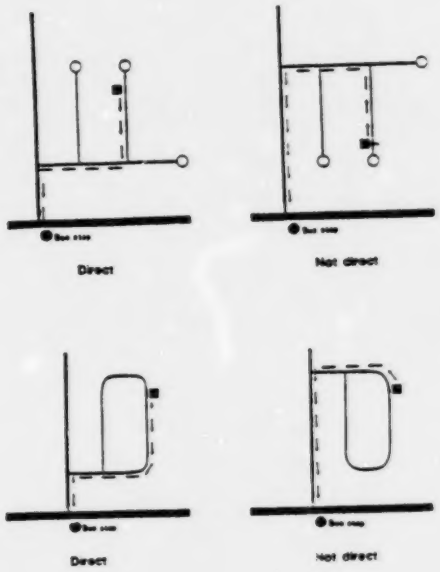
The number of people that use transit is a function of the accessibility of that service to their home. Approximately 400 metres to a bus stop is considered the maximum distance one should be expected to walk.

As a rule of thumb, a community has been well designed from a transit viewpoint if 85% of the community population are within this 400 metre distance and if 40% of transit users are within 200 metres.

Satisfying these distance guidelines is dependent upon the location of the transit route and the bus stops and also the local street design and pedestrian walkway location. The following design principles should be incorporated into the subdivision design guidelines. Subdivision applications should subsequently be reviewed to assess conformity to the basic principles.

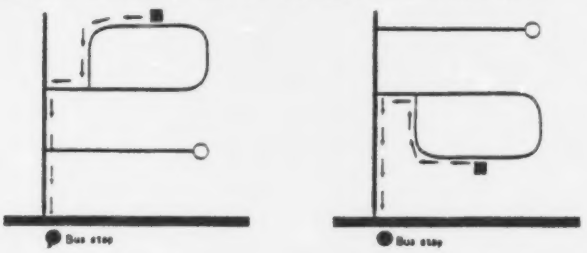
i) Direct/Indirect

Local streets should be direct, avoid backtracking and be oriented towards bus stop locations. Systems designed to discourage automobile penetration can work equally well and still observe this criterion.



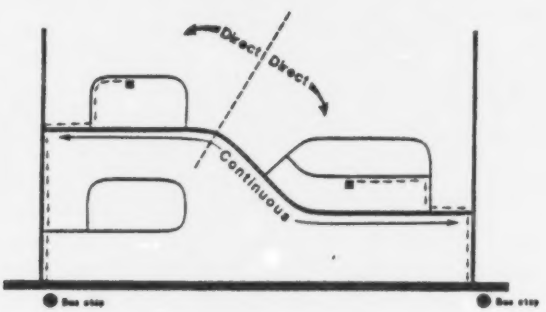
ii) Perceived Walking Distance

Perception of walking distance by the individual is equally important. Different patterns may have similar walking distances but may not be perceived as direct.



SAME WALKING DISTANCE

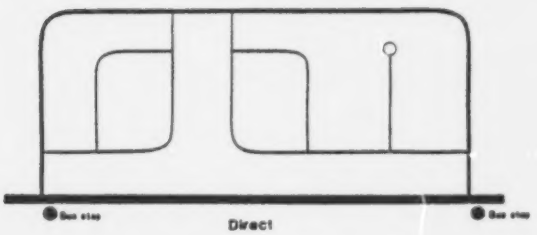
iii) The use of direct routes for pedestrians need not restrict use of continuous street systems within the neighbourhood.

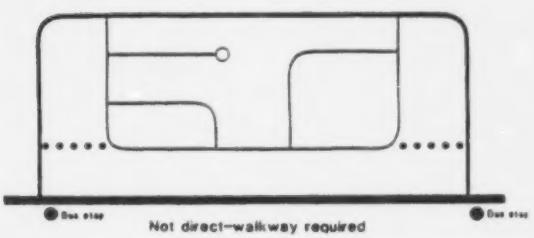


iv) Walkway Provision

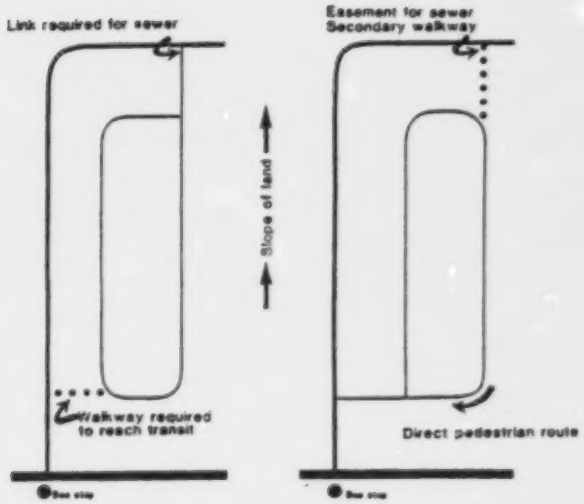
It may be necessary to have pedestrian walkways providing residents with more direct access to a bus stop.

With the Canadian climate it is desirable to provide direct routes along streets, sidewalks and to mimimize use of separate walkways as winter maintenance of walkways can be a problem.





v) In areas where sidewalks are not built along all local streets, the provision of sidewalks should be related to transit stops and walking routes to stops. If topography is a limiting factor for sewer line construction, it may be possible to use an easement for the utilities and still maintain the direct route for vehicles and pedestrians. When walkways are provided they should be built in the initial stages of development.



c) Travel Time

Travel Time is a function of routing type, traffic control, bus stop location, street design and development staging.

The following travel time related design guidelines are recommended.

i) Where traffic volumes are similar along collector or arterial roadways, the routes used by buses, should, wherever possible, have traffic controls favouring transit. For example, where signals are installed, cycle times should be adjusted, if possible, to minimize delay with regard to transit vehicles in the rush hour.

ii) Bus stops should be located on the far side of busy intersections. This minimizes the traffic congestion and allows the bus to take best advantage of green lights if the intersection is signalized or traffic gaps if it is not.

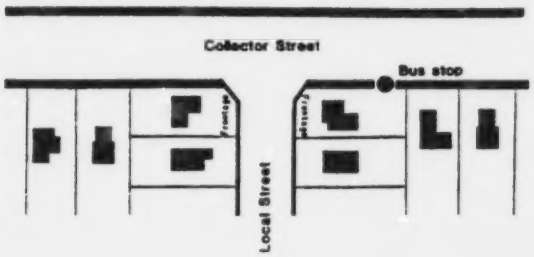
iii) To minimize travel time on roadways used by buses, a good road surface and street geometry should be provided. Both poor road surface and tight turning radii contribute to slower vehicle speeds. The pavement on these streets should be of sufficient depth and quality to carry heavy loads and to reduce as much as possible vibrations which would affect adjacent residences.

iv) To avoid unnecessary travel time, to provide a viable transit service and to satisfy one of the major objectives of having "day one" service to all new urban developments, it is important to develop, as the initial phases, those neighbourhoods adjacent to existing development or arterials through which or on which there are transit routes. This is essential for integrating a new neighbourhood into the transit system, and installing in the minds of new residents, the availability of an attractive transit service.

d) Community Impact

Residents of a community will be more responsive to transit if the routings through their community not only provide good service but do so with minimal disruptive effects. The steps that can be taken in the design of the community and in the location of bus routes and bus stops to minimize these effects are listed below.

i) The houses located on the corner of local and collector streets should be built to face the local street. If a transit route is to run on the collector street and bus stops are required at various intersections along this road, a bus stop on the side yard of the house has less impact than if it were on the front yard.



ii) When people are buying homes in new communities they should be informed of the location of the ultimate bus routings so they are aware of the proximity of their future house to these routes. Some people may not want to live on a bus route. This could be done by indicating the proposed bus route on a zoning sign located at the entrance to the subdivision.

iii) It is desirable in the initial stages of development of new communities to inform residents of the ultimate transit routings. This reduces the overall impact on the community as it develops.

2.3.4 Factors Related to Increased Transit Usage

The actual average energy saving possible through implementing the above guidelines is difficult to determine due to the numerous variables which exist. However, as the cost of implementing the land use planning measures are minimal, all gains through increased public transit usage and reduced automobile usage will be a direct gain to the community. The following summary of findings extracted from Regional Plan News, August 1976 Number 99, "Where Transit Works: Urban Densities For Public Transportation" attempts to quantify some of the factors related to increased public transit usage.

a) Based on energy consumption per seat/kilometre an urban bus has been shown to be at least three times as efficient as an automobile. This

ratio is increased to approximately 10:1 if one assumes low car occupancy and high transit vehicle occupancy.

b) A 50% reduction in trip time will normally increase ridership by 14 to 20 percent.

c) A doubling in the frequency of bus service could increase ridership by 24 to 77 percent.

d) At densities of between 2 and 17 dwellings per hectare transit use is minimal.

e) Transit use increases sharply at densities above 17 dwellings per hectare.

f) The higher the density of the non-residential destination eg. downtown, university campus, industrial park etc. the more chance auto owners will use transit. However, if the destination points become too numerous and dispersed the transit system will not be viable.

With regard to this latter point the City should consider the long range plan for development of employment centres to ensure that it is compatible with the requirement of an efficient transit system.

2.3.5 Residential Streets

In addition to planning residential areas for an efficient public transit system, consideration should be given to the design of the roadways within a neighbourhood or subdivision. Energy conservation can be obtained by:

- Designing the road hierarchy with greater sensitivity to expected traffic volumes;

- reducing the pavement width within the right-of-way where practical; and

- reducing the percentage of developable land used by roads and lanes.

a) Road Hierarchy

The City of Lethbridge and the local development industry are in a position to experiment with more efficient street systems. The main problem lies in the lack of relationship between traffic volumes and the road hierarchy provided. Traffic generation figures are seldom used as a design tool at the subdivision planning stage. In most cases wide streets with parking allowed on both sides have become the accepted norm for single family and semi-detached areas. However, in comprehensively planned multi-family sites considerably reduced standards have been accepted, and have in many cases improved the appearance by placing less emphasis on roads and more emphasis on landscape features and the dwellings themselves. In most residential areas the movement and parking of cars are the dominant features both from the technical and visual aspect. The provision of this overdesign to accommodate the private automobile is expensive both in construction cost and land cost. It is not cost efficient to service a large lot, 10 house cul-de-sac with an 18 m right-of-way, a 10 m paved surface and a 30 m diameter turning bulb, yet this is common practice in Lethbridge and many other Canadian cities. In many areas rear lanes of 8 m or 10 m are also provided.

The difference between residential and other types of roads involve both scale and purpose. Residential streets are an integral part of the housing layout where surroundings, free from traffic nuisance, are of prime importance.

The main object of the local street layout should be:

i) to provide vehicular access to lots with the minimum of danger and nuisance;

ii) to keep vehicle speeds low in the vicinity of homes.

With the above objectives in mind the design of local street networks should be based on:

- the volume and type of traffic generated by the residential area and the main flow direction of this traffic between homes and outside destinations;

- the likelihood of non-local traffic wanting to use the site to take short-cuts;

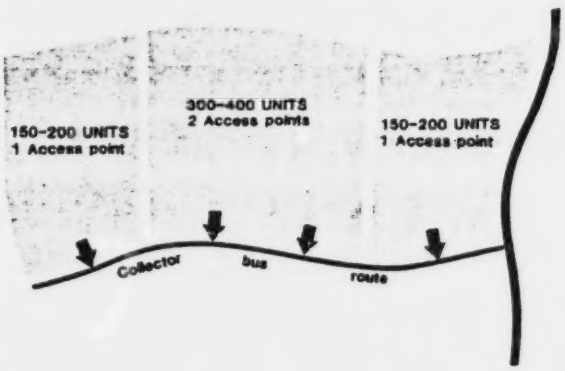
- the location of public transit routes and bus stops;

- the location of community facilities;

- the distribution of density within the neighbourhood see (Section 2.3.3).

From a cost benefit aspect, it is important that each type of road in the hierarchy of streets be related to projected traffic volumes. Roads which

are severely underutilized do not support energy conservation objectives. As a general guideline, local streets with two driving lanes are capable of serving 150-200 housing units. In many cases higher standard and higher cost collector roads could be spaced further apart without any apparent reduction in convenience. The savings from a land consumption and servicing point of view are considerable if the length of collector roads, especially those with no frontage access, can be kept to a minimum. Similarly, linking small cul-de-sacs and crescents directly into the collector road system is inefficient and should be avoided.

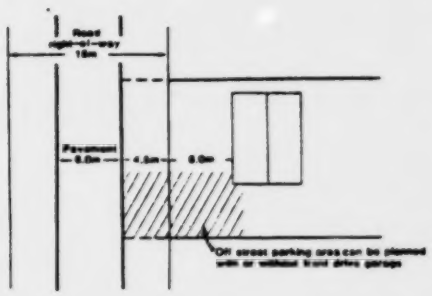


b) Pavement Width

The current 10 m pavement width for residential streets is based on the need for two 2.75 m driving lanes and two 2.25 m parking lanes. If the policy is to continue to provide two parking lanes, the 10 m standard cannot be lowered without reducing safety and convenience. If however, on-street parking could be eliminated by enforcing off-street parking for residents and visitors, the pavement width could be reduced to 6 m. Other than the elimination of street parking, the narrower pavement has several advantages.

i) approximately 30 percent reduction in pavement costs;

ii) apparent increase in front yard space if all lands between the edge of the pavement and the house front are available for landscaping and off-street parking;



iii) reduced scale of the road improves aesthetics,

iv) improved safety - parked vehicles can cause hazards by masking pedestrians and other moving vehicles;

v) more of the utility line network could be located outside the pavement thus facilitating maintenance.

In spite of the positive features associated with narrower pavement widths, it is hard to justify the idea from an energy conservation stand point. The cost of providing extra pavement width accounts for about 3% of the on-site servicing costs of a residential lot. If it is assumed that the servicing costs total 10,000 dollars the cost of the parking lane is approximately 300 dollars. It would be difficult to provide a two car parking space on each lot plus additional visitor parking for this figure. Cost savings from the other factors listed are difficult to determine.

The second and perhaps more difficult problem to overcome is the residents' expectation that on-street parking is permitted. This attitude would not be easy to change and could be the major deterrent in trying to introduce 6 m pavement widths.

In spite of the problems, it is felt that narrower pavements could be introduced in the following situations:

i) small 5-12 lot cul-de-sacs where all houses are designed with a front drive garage or have a wide sideyard for access to the rear of the lot;

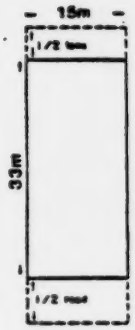
ii) cluster housing or planned unit developments where parking is planned as an integral part of the design.

c) Land Requirements for Roads and Lanes

With good planning and attention to detail, it is possible to design most residential subdivisions with no more than 20% of the developable land used for road right-of-way, assuming the normal 10% dedication for municipal/school reserve. If the development area includes a high proportion of multi-family housing with private road systems, the percentage of public road will be further reduced, however, the overall land required for the combined total of public and private roads should remain at or just below the 20% figure.

The elimination of lanes on rear utility rights-of-way is an important factor in raising the percentage of land available for housing development. The following table compares the various standards for roads and lanes which presently exist in Lethbridge together with a recommended standard which would indirectly improve energy conservation in residential subdivisions. In each case the area of road and/or lane area is shown as a percentage of the lot unit i.e. lot plus ½ road and ½ lane, see figure below.

Lot unit
(assuming 15 x 33m lot)



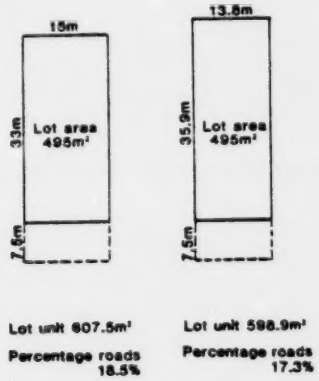
Road R.O.W. Standard	Area of Lot Unit	Area of Road/Lane	Road & Lane % of Lot Unit	Net Density (units/ha)
17 m (10 m lane)	697.5m^2	202.5m^2	29%	14.3
18 m (8 m lane)	690.0m^2	195.0m^2	28%	14.5
17m (7m lane)	675.0m^2	180.0m^2	26.6%	14.8
20 m (Village II)	645.0m^2	150.0m^2	23.25%	15.5
18 m (Village III)	630.0m^2	135.0m^2	21.43%	15.9
15 m (Recommended)	607.5m^2	112.5m^2	18.5%	16.5

The 15 m right-of-way (no lane) standard suggested, will provide approximately a 15 percent increase in net density over the current laned subdivisions, assuming similar lot sizes are used. Servicing can still be accommodated in the street with a 3.5 m front easement for gas and A.G.T. Overall the area required for road/lane rights-of-way has been reduced by 45% when compared to the 17 m road and 10 m lane local street standard.

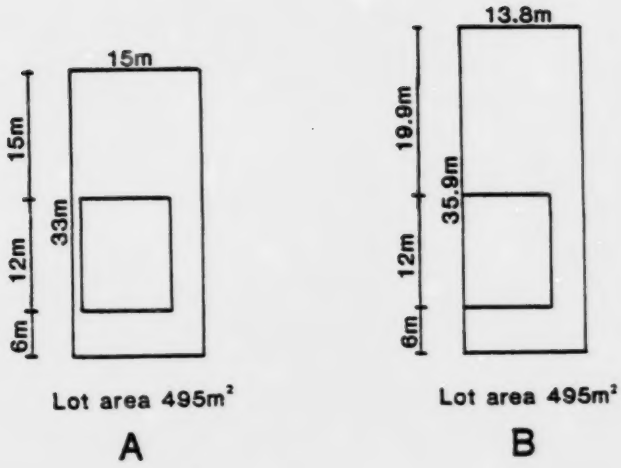
d) Lot Shape - Although lot shape is not directly related to the road and lane requirement, the shape of the lot does effect the density to some degree and should be considered with the above guidelines on rights-of-way. From an energy conservation standpoint it is better to

increase lot depth rather than lot width to obtain the same lot area. For many years the "front foot" cost has been the standard reference for lot pricing. The narrower the lot the more houses can be serviced from the road and utility lines.

In the diagram below the basic lot unit which includes half the right-of-way (7.5 m) and a 15 m x 33 m (495 m^2) lot is compared in terms of percentage road right-of-way with a narrower lot of 13.8 m x 35.9 m (495 m^2).



In this example, by reducing the lot width by the width of a side yard and adding extra depth to retain the same lot area, an 8% saving in area of roads per lot and a 1.4% improvement in net density is achieved. This is equivalent to a gain of approximately 1 ha. in a 65 ha. housing area. If the above example was also to incorporate a zero side yard principle, further gains can be made in usable yard space given similar sized houses.



In Example A with a 15 m wide lot and 1.2 m side yard the usable rear yard space is 225 m^2. In Example B with a 13.8 m wide lot and no side yard, the usable rear yard space is 247 m^2 a 9.7% increase. In both examples the right hand side yard and overall lot area remains the same. A small reduction in front yard area of 7.2 m^2 is the only real loss.

Therefore, lot shape is an important factor in developing more land efficient subdivisions. A slightly narrower but deeper lot reduces the ratio of roads to lots, increases density and can with a zero side yard layout provide more usable yard space. This can be achieved with no reduction in the lot area. Combining the 15 m right-of-way with the slightly narrower lot of 13.8 m shown in the above example, a net density of 16.7 units per hectare is achieved (using the 495 m^2 lot). A further increase in overall density of approximately 2 to 3 percent should be possible in most subdivisions by minimizing unusable road frontage and spacing the collector road system based on traffic volumes and number of units served.

The importance of these gains can be illustrated by evaluating the impact from a financial point of view.

Using a simplified example of two 20 hectare residential subdivisions the following calculations illustrate the impact of the more efficient lotting and reduced rights-of-way explained previously.

DESIGN NO. 1 (Subdivision with 17 m road right-of-way and 10 m lanes
Area of Lots 495m^2 Frontage 15 m)

Residential	12.5 hectares (252 lots)
Reserve	2 hectares
Commercial	0.5 hectares
Road Right-of-Way	5 hectares
TOTAL Gross Area	20 hectares

DESIGN NO. 2 (Subdivision with 15 m road right-of-way and modified lots
Area of Lots 495m^2 Frontage 13.8 m)

Residential	14.5 hectares (293 lots)
Reserve	2 hectares
Commercial	0.5 hectares
Road Right-of-Way	3 hectares
TOTAL Gross Area	20 hectares

The improvement in lot yield from 252 lots (Design 1) to 293 lots (Design 2) would provide an additional 41 lots or approximately one million dollars in serviced lot sales. If the cost of servicing is subtracted from this, the net land value of the additional residential area is $615,000 or approximately 2,100 dollars per lot. This money could be used to provide direct assistance

to builders or to homeowners for the incorporation of energy conservation construction techniques in the housing unit. (Calculations assume average lot price of $25,000 and servicing costs of $10,000 per lot). An additional $32,000 could be realized per year from increased property tax revenues of the 41 housing units. Operation and maintenance cost for the subdivision should not increase significantly because there is no proportionate increase in street length. If those gains are multiplied over the total subdivision activity in a 5 or 10 year period the savings could be substantial.

e) Conclusions

The three most important factors in improving energy efficiency from a neighbourhood and subdivision point of view in the City of Lethbridge are:

i) the planning of an integrated public transit system and land use plan for each neighbourhood;

ii) the increasing of residential densities through more efficient subdivision designs;

iii) the elimination of lanes and the reduction in local road rights-of-way.

From an energy efficiency viewpoint, a public transit system which is well used and works efficiently within the community, will be a major asset. The large gains will be over the long term. Trying to "retrofit" an efficient public transit system into an established land use pattern is extremely difficult. Fortunately, many of the principles involved in planning neighbourhoods to accommodate transit are also effective in reducing trip lengths for all vehicles, encouraging more walking and bicycle trips and supporting community facilities both at the neighbourhood level and in the downtown.

With respect to increased densities, it has been noted that several measures could be implemented in Lethbridge to reduce the area of land required for roads in relation to housing area. A reduction in the right-of-way standards to 15 m and the elimination of lanes will have a substantial impact on residential densities. Further gains can be obtained by optimizing the usable road frontage and introducing innovative designs such as cluster housing. The cost savings obtained through these measures could be used in energy efficient housing program development and further implementation of the strategy in general. Some form of a revolving fund could be established to achieve this continued program.

f) Subdivision Guidelines

The measures which should be incorporated at the Area Structure Redevelopment Plan Stage have been outlined previously and do not need further elaboration.

For the purposes of reviewing subdivision and informing applicants of the City's requirements the Planning Department should prepare a subdivision application guide. Apart from indicating the normal requirements of scale, land use, density, lot yield etc. the guide should set out some basic requirements for statistical information on energy conservation. The following infor nation should be provided.

1. The usable street frontage ratio. In this efficiency test the maximum possible is 2:1 where both sides of a street have frontage. In large subdivisions with intersections, reserve parcels etc. the realistic target would be approximately 1.6:1.

2. Overall percentage of road right-of-way to developable land. As noted earlier an efficient subdivision should not have more than 20% of its area in roads.

3. Tentative bus route and bus stop locations in coordination with the City Transit Department and policies established in the Area Structure Plan.

4. Density distribution in relation to the proposed bus route and bus stops for the neighbourhood. The target figure suggested is 75% to 85% of the population within 400 m of a bus stop.

5. Location of walkway and overall pedestrian system in relation to the bus stops.

6. Traffic generation figures related to local and collector streets in the subdivision. Based on the guidelines shown in this document, further assessment by the City staff on road layout and efficiency, will be required. The aim here is to avoid construction of roads which will be underutilized, particularly collector roads.

7. Percentage of lots with solar orientation. In all cases the figure should be above 50% with 85% being a more realistic target.

2.4 Subdivision Servicing

The purpose of this section is to examine the means by which present subdivision servicing techniques might be modified to effect energy savings. The examination will cover both "direct" energy savings such as reductions in the power consumption of street lighting and "indirect" energy savings such as reduction of the use of non-renewable resources.

The "indirect" savings which involve reductions in capital costs, may be transferred to the homeowner through some form of incentive program, so that "direct" energy savings in the home may be effected. Where the City is

the developer, servicing cost savings can be passed on to the lot purchaser in that area directly.

It is not within the scope of this study to quantify direct or indirect energy savings and there will be no attempt made to arrive at specific dollar values, except where these have already been generated. However, an attempt will be made to evaluate possible savings as being either significant or not significant, and to identify any items which might merit further detailed study.

Each major item in subdivision servicing will be examined in turn with some conclusions and recommendations for modification of present practices.

2.4.1 Roadways

The one immediate factor in the building of roadways which affects the total energy picture is the quantity of bituminous material used. Broad-scale reduction in the use of this material will have significant impact on the petroleum resource. In the case of residential subdivisions, the savings are considered only in terms of capital costs and/or maintenance costs. Reduction can be achieved in two ways:

- narrower pavement widths and smaller pavement thicknesses
- use of concrete pavement

Present City of Lethbridge standards require a minimum of 50 mm thickness of asphaltic pavement for local roads. It is felt that this is a reasonable minimum thickness and any reductions would inevitably result in increased maintenance.

Present City standards for minimum road widths for local roads are shown on page 2-33.

In the case of a subdivision with lots large enough to provide on-site driveways (minimum 12 m frontage), it is felt that as narrow as a 6 metre paved surface will provide adequate two-way driving with no on-street parking. Occasional widenings at specified intervals may be provided for visitor parking. Most comprehensive multi family developments are designed on this principle.

As previously recommended, the right-of-way requirement may also be reduced to 15 metres, still allowing an adequate width for boulevards, sidewalks and shallow utilities.

Concrete roads have been used widely for expressways and highways but are not common for local roads in Alberta. Historically, until oil prices took a significant rise, the concrete road has been considerably costlier to install. At this point in time a concrete road is still costlier to install but it has the advantage of significantly lower maintenance costs. While asphalt surfaces are maintained annually, the concrete surface can last for many years with virtually no maintenance. Maintenance of major utilities under a concrete roadway is costlier, but with narrower driving surfaces and wider boulevards, it is possible to install all utilities in the boulevards.

Conclusions

a) minimum right-of-way requirements for local roads may be reduced to 15 metres.

b) minimum driving surfaces for cul-de-sacs and small crescents may be reduced to 6 metres provided on-site parking is feasible and enforced.

c) laned subdivisions are not recommended and should be discouraged as they result in increased capital and maintenance costs.

d) the data to date on concrete roadways for local roads is insufficient to make a credible comparison.

2.4.2 Street Lighting

Direct energy savings are possible with the use of high pressure sodium street lights and replacement of mercury vapour street lights. A study carried out by the Utility Director for the City of Lethbridge in February 1981 examines the cost benefits in detail. The study showed that replacement of existing lighting with high-pressure sodium lights was indeed cost effective and would nearly halve power consumption. It recommended a five-year program for replacement throughout the City.

Capital savings may also be incurred by reductions in general lighting levels for local roads and increased spacing of lamp-posts. Reductions should be moderated however, and should not reduce safety or security.

Conclusions

a) direct energy savings are possible with more energy-efficient lamps.

b) capital and maintenance costs may be reduced with marginally lower lighting levels.

2.4.3 Shallow Utilities

The present system of shallow bury for power lines, gas lines, telephone lines and cable TV does not appear to have any signficant possibilities for energy reduction.

Capital costs may be reduced by the use of overhead power lines but this is offset by increased maintenance costs and loss of aesthetics. A common trench approach for these utilities is presently being used.

The only major conclusion in this area is that where possible the shallow bury utilities be located in boulevards to reduce any resurfacing costs resulting from normal maintenance procedures.

2.4.4 Waterworks

The size of watermains in residential subdivisions is largely governed by fire flow requirements and the necessity to provide large flows to hydrants. If present fire flow requirements are to be met, there is little scope for reducing costs significantly in this area.

In the broader scope, the use of plastics in the manufacture of pipe has become common. The manufacture of plastic pipe does use a valuable energy resource. Because of its present low costs and ease of handling and installation, it is not envisioned that wide-spread usage of this pipe will be discouraged.

The one area where energy savings may be effected is in the area of system pressures. People, over the years, have come to expect and demand greater water pressures for their homes. Energy is required, in terms of pumping costs, to achieve these pressures. While pressures of 60-80 psi in the home are now considered desirable, it is felt that pressures in the order of 40-50 psi should be entirely acceptable and still provide adequate fire flows. It is recommended that the City isolate a test area for reduced pressures in order to determine user satisfaction before proceeding with any widespread program.

Consumption of water has also been on the increase, in part due to high pressures. Metering of services has been used effectively to discourage high consumption, in combination with various types of incentive programs.

Consideration should be given to encouraging conservation of power and water by re-orienting the basis for utility charges. Due to the existance of a "minimum charge" there is no real incentive to conserve. Furthermore, commercial rates encourage high usage by reducing the unit rate after "x" amount has been consumed. It should be noted however that severe reduction in consumption under a sliding scale rate may not generate sufficient revenue to support the system.

Conclusion

Direct energy savings may be effected by general reductions in system pressures and adjustment to billing practices. It will be necessary to determine public acceptance before implementation.

2.4.5 Sanitary Sewers

Gravity sewer systems have traditionally been energy effective and the only energy requirement has been in the use of pumping stations. The obvious rule of thumb is to avoid pumping stations wherever possible. One way of effecting reductions in pumping stations is to allow flatter grades.

Present Provincial Guidelines require a design for a minimum full flow velocity of 2.5 feet per second. However, many municipalities have installed sewers at much flatter grades with no appreciable increase in blockages or maintenance costs. The Municipality of Delta (because of flat land and high water table) have used 200 mm sewers at gradients of 0.14% with no recorded increase in blockages, and other Municipalities have had

similar experience. It is suggested that where flatter grades offer economy or elimination of pumping requirement, the minimum grade for a 200 mm local sewer be accepted at 0.20% and where site conditions allow sufficient gradients the minimum requirement be 0.40%. In flat areas this would also allow more land to be serviced without pumping.

Energy savings are also possible at downstream treatment and disposal works. It is beyond the scope of this study to examine the energy efficiency of various treatment methods. Generally a reduction in the volume of flow will reduce overall power requirements. Reductions in volumes may be effected by implementation of a water conservation incentive program and by reduction of infiltration in sanitary sewers. Infiltration has historically been a problem in sanitary sewers.

In examining the various methods available to limit infiltration, it appears that the only significant method is to enforce strict original installation.

Conclusions

a) limit pump statons by allowing flatter grades

b) reduce volumes by water conservation

c) reduce infiltration by on-site inspection during construction.

2.4.6 Storm Drainage

Similar comments apply to storm sewer systems as to sanitary sewers. Energy may be saved by limiting pump stations where possible. In addition, the concepts of overland flow and stormwater management have had more widespread usage over recent years.

Practical application of storm water management is still in a state of evolution and many ambitious projects have resulted in the "cure" becoming more painful than the disease. Detailed examination of these practices is beyond the scope of this study. Such ideas as discharge of roof drains to lawns, grass swales for overland flow, etc., are generally desirable concepts because they tend to reflect natural stormwater retention situations. Stress is placed on the fact that drainage requirements are site specific and the whole design should reflect the best compromise for a particular development. The adoption of a two-year storm recurrence curve for the piped system design rather than the widely used 5-year curve, will not effect any appreciable savings within an average subdivision, but will make significant savings downstream.

Present projections are that a day will come when storm run-off will require treatment before discharge to a watercourse because of its increasingly high pollution load. In principle, it makes sense now to use design methods which will limit the quantity of run-off that reaches the piped system and might require future treatment.

Present experiences with retention ponds indicates the following potential problems:

- maintenance costs
- algae growth
- mosquito breeding
- liability for hazards created

While these problems may be resolved, it is suggested that retention pond proposals be carefully reviewed before approval.

Conclusion

a) encourage on-site run-off attenuation techniques.

b) exercise caution in reviewing proposals for large retention ponds to be maintained by the municipality.

2.5 **Site Planning Guidelines** (Reference 2)

The site planning guidelines related to energy conservation are based on three primary factors, solar orientation, solar access and exposure to wind. The frequent high winds in the Lethbridge area may make wind protection equally important to solar gain. The following subsection sets out those planning factors which are considered to be important in the Lethbridge context.

2.5.1 Solar Access and Orientation

With respect to solar access and orientation it is important to note the following points.

a) The amount of energy which can be gained from the sun in the winter months at latitude 50° N is very small.

b) Good solar access in the spring and fall may be more important than trying to maintain access through the winter months.

c) In Lethbridge the angle of the sun above the horizon at 12 noon on December 21st is 17°. The length of shadow cast by the sun at this angle is extremely long making solar access protection difficult during the winter months.

Practical application of storm water management is still in a state of evolution and many ambitious projects have resulted in the "cure" becoming more painful than the disease. Detailed examination of these practices is beyond the scope of this study. Such ideas as discharge of roof drains to lawns, grass swales for overland flow, etc., are generally desirable concepts because they tend to reflect natural stormwater retention situations. Stress is placed on the fact that drainage requirements are site specific and the whole design should reflect the best compromise for a particular development. The adoption of a two-year storm recurrence curve for the piped system design rather than the widely used 5-year curve, will not effect any appreciable savings within an average subdivision, but will make significant savings downstream.

Present projections are that a day will come when storm run-off will require treatment before discharge to a watercourse because of its increasingly high pollution load. In principle, it makes sense now to use design methods which will limit the quantity of run-off that reaches the piped system and might require future treatment.

Present experiences with retention ponds indicates the following potential problems:

- maintenance costs
- algae growth
- mosquito breeding
- liability for hazards created

While these problems may be resolved, it is suggested that retention pond proposals be carefully reviewed before approval.

Conclusion

a) encourage on-site run-off attenuation techniques.

b) exercise caution in reviewing proposals for large retention ponds to be maintained by the municipality.

2.5 **Site Planning Guidelines** (Reference 2)

The site planning guidelines related to energy conservation are based on three primary factors, solar orientation, solar access and exposure to wind. The frequent high winds in the Lethbridge area may make wind protection equally important to solar gain. The following subsection sets out those planning factors which are considered to be important in the Lethbridge context.

2.5.1 Solar Access and Orientation

With respect to solar access and orientation it is important to note the following points.

a) The amount of energy which can be gained from the sun in the winter months at latitude 50° N is very small.

b) Good solar access in the spring and fall may be more important than trying to maintain access through the winter months.

c) In Lethbridge the angle of the sun above the horizon at 12 noon on December 21st is 17°. The length of shadow cast by the sun at this angle is extremely long making solar access protection difficult during the winter months.

d) In winter the azimuth is small creating a relatively small arc through which the sun travels above the horizon.

e) Topography can modify greatly the ability to achieve solar gain.

f) The term "solar skyspace" is used to define the area which must be protected from shading. The sky space is defined by the solar analysis of azimuth and altitude.

g) Other factors including environmental protection, development density, and view protection may be more important to individuals and the community in general than comprehensive solar access.

2.5.2 Design Guidelines

a) Shadow Calculations

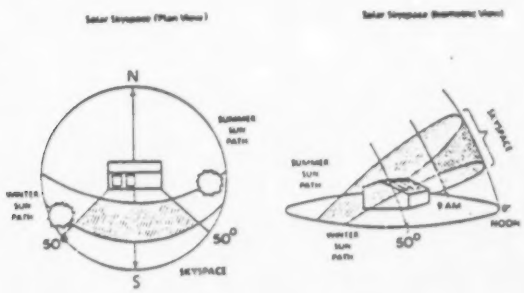
In order to determine the viability of solar access and orientation the planner will need to calculate shadow patterns for the site development plans that are submitted. Normally, if solar access is protected in the winter it will also be protected in the summer. Appendix A sets out the calculation procedure for shadow patterns. The information is from the "Guidebook of Protecting Solar Access For Residential Development", U.S. Department of Housing and Urban Development. The following diagrams from this publication illustrate the principle of solar skyspace which is directly related to assessing permitted shadows cast by adjacent buildings and trees. It should be noted that the protection of solar access at sun altitudes below 12° is not recommended due to the minimal energy gain achieved. Also, it is important when measuring the potential shadows cast by trees to consider the height of the tree at maturity.

b) Conflicting Policies

Earlier, brief mention was made of possible conflicts between achieving energy conservation through site planning and other community goals and policies. The following points cover some of the more important conflicts which may arise.

i) Even in areas of good solar access development should be discouraged if steep and unstable slopes create a possible hazard.

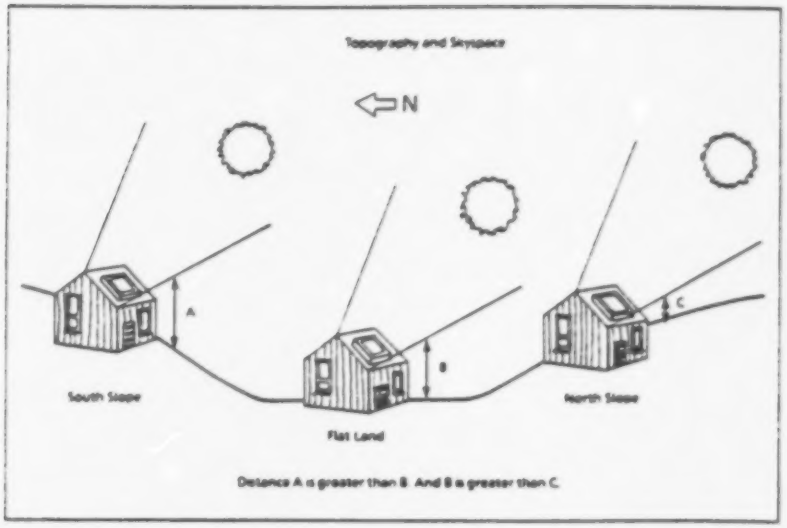
ii) Trees should not normally be sacrificed to provide solar access unless they have a short life expectancy.



RECOMMENDED SKYSPACE ANGLES

Latitude	Azimuth	Altitude	Noon Altitude	Percent Radiation
50	50°	12°	17°	87°

Note: the 12 degree altitude applies only to those months when the sun's path is 12 degrees above the horizon within the 50 degree azimuth angles. The radiation figure is based on the percentage of total available radiation falling on a horizontal surface on December 21st.



SOURCE:

PROTECTING SOLAR ACCESS FOR RESIDENTIAL DEVELOPMENT, A GUIDEBOOK FOR PLANNING OFFICIALS, U. S. Department of Housing and Urban Development.

iii) High density development, with tall buildings and long shadows, may cause solar access problems for buildings to the north. However, the energy efficiency of the more dense development may be greater than the loss of some solar access to a few buildings. Naturally the best solution is to plan taller buildings on the north side of developments where the cast shadows impact can be better addressed.

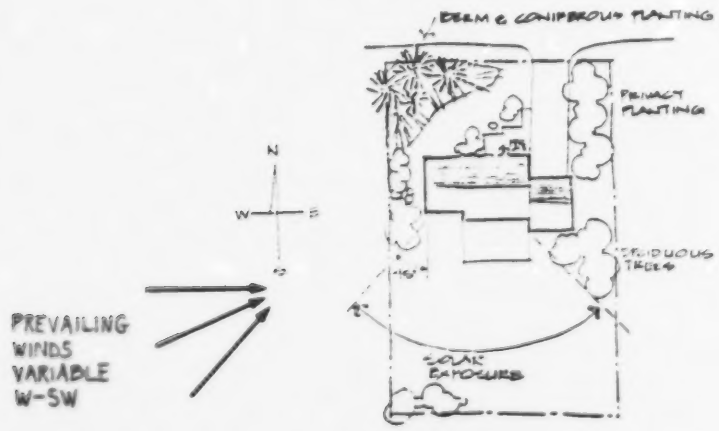
iv) The planner should be aware of attempts to use solar access as the basis to seek exclusive zoning.

v) Architectural controls can conflict with solar access goals. Usually there are architectural solutions that can be employed to

resolve the conflicts. However, the relative importance of solar access and orientation as compared with other factors must be remembered. For example, a house which is well insulated and airtight can still be extremely energy efficient even though it faces west or east to take advantage of a view.

vi) Another major area of concern in evaluating site plans with respect to solar access and orientation will be the details of site landscaping applied for privacy and aesthetic reasons. Privacy zones may be on the south side of a dwelling, thereby creating the need for screen planting, fences, berms, etc. These elements may conflict with solar access. If there is a privacy requirement and the desire for an aesthetic surrounding for a single family or multiple family dwelling, the solar access may very well have to be sacrificed.

vii) Protection from cold winter winds in Lethbridge may conserve as much energy as that saved through solar orientation. The prevailing winter winds are not from the south, thus permitting planting, berming and fencing to shelter dwellings from the wind without blocking solar access. The figure below illustrates a typical lot situation and how solar access and wind protection can be achieved.



Similar planting schemes can be applied to low rise multiple dwellings. It should be noted again that such measures are not substitutes for proper construction and insulation, however, they should likely be given equal weight with solar access and orientation.

A review of the current situation with regard to potential conflicts between energy retrofit measures and municipal by-laws is contained in Appendix A3.

c) Development Processing

In order to aid the review process for site plans with respect to solar access and orientation, the following information should be submitted by the applicant for subdivision and/or development approval, in addition to the standard requirements currently contained in the respective subdivision and land-use regulations.

i) A location map showing the site in relation to adjacent structures, trees and topography;

ii) A shadow calculation based on these adjacent uses (this may not be easy to obtain from the applicant);

iii) A site plan showing all proposed structures and planting;

iv) Micro climate data indicating prevailing winds, solar exposure etc;

v) Potential solar access conflicts and mitigation measures proposed.

Throughout this process, if solar orientation and access are to be important issues, then the applicant or his designate should be informed by City staff as to the requirements being sought. A good working relationship between the applicant and City staff should permit a reasonably smooth process to evolve.

2.5.3 Land Use By-Law Guidelines

There are some serious complications which arise when attempting to control solar access or orientation through the use of zoning or land use by-law regulations. In existing built-up areas it is nearly impossible, expecially at 50° N latitude.

A situation has developed in a large metropolitan centre in Ontario where a proposed by-law to provide solar access, if implemented, would have meant that resident "A" would spend some $500 every three or four years to keep his trees pruned to an acceptable height, so resident "B" might gain less than $10 per year in energy costs from solar gain through his south facing windows. Obviously the by-law is under review and modification. In existing developed areas in Lethbridge, where there are a number of large trees, a similar situation may occur in attempting to control solar-access.

On the positive side consideration should be given to the following by-law related factors.

a) Examining Architectural and Historic Preservation Controls

Those areas in Lethbridge that are or may be in future protected by either architectural or historic preservation controls should be looked at carefully with respect to solar access.

The architectural or historic significance of a structure may take precedence over solar energy considerations. If on the other hand modifications can be made to the structure without seriously altering its character then such alternatives should be permitted.

b) In some instances it may be necessary to relax the by-law height restrictions to allow for roof top installation of active solar equipment. This measure will usually only be necessary on flat roof structures which are already at or near the maximum height allowed under the by-law.

c) Side Yard

As with the height restrictions, some relaxation in the side and front yard setbacks should be permitted for apparatus used for active or passive solar systems. Additional roof overhangs or front greenhouses are two examples where relaxation may be required.

d) Lot Coverage

Again, the existing waiver provisions at the discretion of the Municipal Planning Commission can be used to allow the placement of energy conservation apparatus which might otherwise infringe on lot coverage regulations.

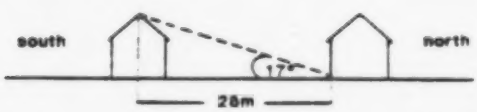
2.5.4 Zoning

The measures discussed above require some relaxation or elimination of certain barriers to the use of solar systems. However, the changing of zoning to protect solar access is more radical and should be approached with caution. Zoning changes to existing developed areas to provide for solar access are not recommended. The creation of numerous non-conforming structures will create many problems for the City. In winter with a maximum sun angle of 17° a 8.5 m building will cast a shadow approximately 28 m long. Trying to protect solar access under these conditions would be extremely difficult if reasonable development densities were to be maintained.

In new development areas there are some measures which can be taken to improve solar access.

a) Deeper Lots

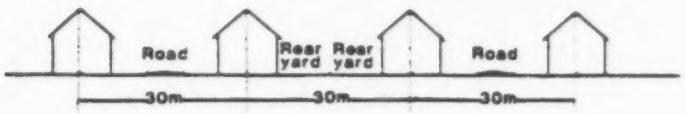
On east/west streets, increased lot depth will help to provide better solar access due to the separation between houses. The aim here is to obtain a separation of at least 28 m between the highest point of the house to the south and the rear wall of the house to the north. This arrangement will ensure a few hours of sunlight between say 11 am and 1 pm. Before and after these hours the sun will be lower in the sky and obscured by adjacent houses. With this separation, good solar access will be possible during the spring and fall when the maximum benefit can be obtained.



As explained previously the deeper but narrower lot also has benefits in terms of subdivision design efficiency and improved density.

b) Equalized Access

Under this technique, the space between houses accross the street and between backs of houses is equalized. In Lethbridge with the recommended 15 m roads and a front yard setback of 7.5 m, a 30 m separation will be achieved. This is close to the separation recommended for the rear. In this situation it would not be advisable to regulate equalized access since the normal lotting arrangement will produce almost the same results. Again, it should be remembered that this is only applicable to east/west oriented streets.



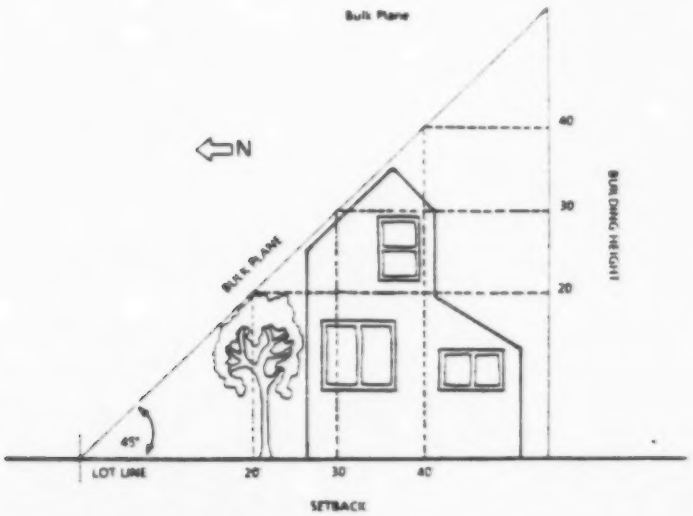
c) Performance Standards

Performance standards are another way to protect solar access. Under this provision there is a maximum level of shading that can be caused by developing a new lot. It is believed that this approach would not be easy to implement as existing trees and buildings that shade a collector or window would be considered non-conforming. New buildings or vegetation that would cause shading are prohibited. These provisions would not be easy to adminster and are, therefore, not recommended for general use.

d) Using Bulk Plane Provisions

The traditional building envelope is defined by one uniform maximum height and the setback lines. This retangular or square box is the area in which a building can be constructed. The bulk plane is a modification to this building envelope. As setback increases, height can increase without shading other lots.

Bulk plans are not new and have been used for many years, in New York City to regulate skyscrapers, primarily for light and air. The buildable area is defined by using bulk plane regulations. A pyramid type plane can also be used with planes sloping evenly on all four sides. There are so many variables that can effect envelope dimension it seems appropriate to use the computer to generate the specific bulk plane angles and heights for varying lot dimensions, orientations and topographic consideratons. The bulk plane envelope is useful in regulating solar access for multi-family housing, expecially where roof top access to the sun is the objective.



SOURCE:

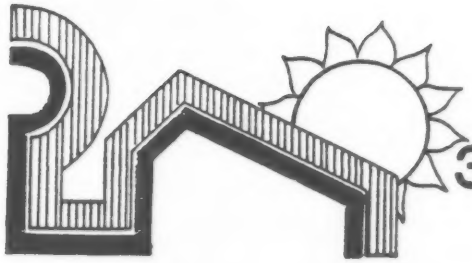
PROTECTING SOLAR ACCESS FOR RESIDENTIAL DEVELOPMENT, A GUIDEBOOK FOR PLANNING OFFICIALS, U. S. Department of Housing and Urban Development.

With respect to multi-family development and attached houses it is recommended that these be given special zoning such as RCSL or PUD. Each development can be reviewed prior to approvals to ensure that the development density and orientation are acceptable. Again, the general principle applies if density and amenity objectives can be met in several designs, the most energy efficient option should be selected. However, orientation should not normally take precedence over density or the marketability aspect of the project.

REFERENCES

1. In this section, information has been drawn from a number of sources including Subdivision Design Guidelines to Facilitate Transit Services Ministry of State For Urban Affairs, Working Paper, March, 1977: Community Planning For Public Transit, Department of Municipal Affairs - British Columbia: Metropolitan Toronto Transportation, Energy Study Wilbur Smith and Associates.

2. The primary reference document for this section, is Protecting Solar Access for Residential Development. A Guidebook for Planning Officials - U.S. Department of Housing and Urban Development. Office of Policy Development and Research. In Cooperation with the U.S. Department of Energy.



3.0 Guidelines for Housing Construction

3.0 GUIDELINES FOR HOUSING CONSTRUCTION

3.1 Energy Conserving Residential Structures For The City of Lethbridge - An Analysis

3.1.1 Background

Energy conserving, or energy efficient structures are a relatively new phenomena which have emerged over the past five years. The concepts of low energy demand structures, and the associated technologies, have now been tested and their relative values established. At this point in time, the concept is technically ready to enter the market place.

Traditionally, energy efficiency has not been a concern of the designer, planner or contractor. The industry has not been aware of energy usage and currently, there are no 'rules of thumb' which govern energy efficiency, and ensure that this efficiency is built into the structure. These 'rules of thumb' for energy efficiency must evolve in the complex building industry, so that every actor, from subtrade to consumer, can play their part in adding this new quality to construction practice.

It will be difficult to move immediately to energy conserving housing, in view of the low present cost of home heating; the lack of public awareness about the techniques to reduce energy requirements; the lack of supporting codes and bylaws; the lack of an educational infrastructure, the depressed state of the industry, and the high current cost of new homes.

There is no question that energy efficiency will become one more quality added to home construction. There is a question regarding the speed at which this new concept will be adopted, and who will absorb the costs associated with its implementation.

Recognizing the difficulties of implementing a technology in transition, the purpose of this study is to define the parameters for energy efficient construction practices for The City of Lethbridge. These parameters must be defined in view of the existing impediments against implementing this concept, and yet form the basis for an energy efficient housing stock in the future.

Following is a description of the methodology employed to analyze these parameters for energy efficiency, and the conclusions reached.

3.1.2 Methodology

a) Data Collection

The following data was collected and is presented in the attached appendices B1, B2, B3, B4.

i) Electrical and natural gas consumption figures for the City of Lethbridge and Hotcan computer runs.

ii) Environmental data for the City of Lethbridge and Suffield.

iii) Predicted energy cost increases to the year 2001.

iv) A sample survey of Lethbridge residential contractors to define typical construction practices and levels of energy conservation awareness.

b) Energy Conservation Housing Alternatives

Through the interviews with contractors and City officials, it was determined that a 100 square meter (1078 square foot) bungalow represents a 'standard' Lethbridge home. For the purpose of this study, this standard home was modelled using a computer program to determine the energy performance of this house as various configurations of insulation, air tightness, heat recovery and window glazings were added. The 'standard' was considered to be constructed to Alberta Building Code Energy Requirements.

Six different energy conservation strategies were then applied to the standard house. Each of these strategies incrementally increased the conservation features of the model house. The conservation strategies chosen were based on previous conservation precedents, as established by HUDAC, the Saskatchewan Home Energy Loan Program (HELP), and the super insulated house as developed by the National Research Council. Each conservation strategy included an air tight vapour barrier and mechanical ventilation as a minimum requirement. Each strategy was then analyzed with and without heat recovery through an air-to-air heat exchanger.

Each different conservation strategy was then priced, and an incremental cost for each strategy was determined.

The cost of each conservation strategy was calculated using prices of goods and services from Lethbridge when available, and from Regina when the practice or technology was not commonly available in Alberta. The conservation contractors or suppliers from Regina each had previous experience with the particular service or technology in question.

A list of the conservation measures and incremental costs for each strategy appears in the following Table 3.1. House models Nos. 1, 2, 3, 4, 5, 6, 7 and 12 represent the conservation strategies described above, as applied to the standard house. House models 8 through 11D are developed in the following sections.

TABLE 3.1

HOUSING CONSERVATION STRATEGIES APPLIED TO THE MODEL HOUSE AND INCREMENTAL COSTS BEYOND THE ALBERTA BUILDING CODE STANDARDS

HOUSE MODEL NO.	CODE OR RECOMMENDED STANDARD	R VALUE WALLS	R VALUE CEILING	R VALUE BASEMENT	NATURAL AIR CHANGES PER HOUR ACH	SEASONAL FURNACE EFFICIENCY	MECHANICAL VENTILATION	INCREMENTAL CONSTRUCTION COST
1	Alberta Building Code	R12 R_{SI} 2.1	R34 R_{SI} 6.0	R8/R_{SI} 1.4 Two Feet Below Grade	.5 ACH	55%	NO	-
2	Alberta Building Code Plus Air Tight Construction	R12 R_{SI} 2.1	R34 R_{SI} 6.0	R8/R_{SI} 1.4 Two Feet Below Grade	.1 ACH	65%	YES	$1,762.00
3	As Above Plus Heat Recovery	R12 R_{SI} 2.1	R34 R_{SI} 6.0	R8/R_{SI} 1.4 Two Feet Below Grade	.1 ACH	65%	YES	$2,962.00
4	Hudac Recommendations Plus Air Tightness	R20 R_{SI} 3.5	R34 R_{SI} 6.0	R12 R_{SI} 2.1	.1 ACH	65%	YES	$2,615.00
5	As Above Plus Heat Recovery	R20 R_{SI} 3.5	R34 R_{SI} 6.0	R12 R_{SI} 2.1	.1 ACH	65%	YES	$3,815.00
6	Saskatchewan Home Energy Loan Program Standards, Triple Glazing	R28 R_{SI} 4.9	R40 R_{SI} 7.0	R20 R_{SI} 3.5	.1 ACH	65%	YES	$3,905.00

HOUSE MODEL NO.	CODE OR RECOMMENDED STANDARD	R VALUE WALLS	R VALUE CEILING	R VALUE BASEMENT	NATURAL AIR CHANGES PER HOUR ACH	SEASONAL FUNACE EFFICIENCY	MECHANICAL VENTILATION	INCREMENTAL CONSTRUCTION COST
7	As Above Plus Heat Recovery	R28 R_{SI} 4.9	R40 R_{SI} 7.0	R20 R_{SI} 3.5	.1 ACH	65%	YES	$5,105.00
8	Proposed Lethbridge Measures With Triple Glazings & 1.2 m of Perimeter Basement Floor Insulation	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 $\frac{R_{SI}\ 3.5}{R7.5^{*}}$ R_{SI}1.3	.1 ACH	65%	YES	$3,921.00
9	As Above Plus Heat Recovery	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 $\frac{R_{SI}\ 3.5}{R7.5^{*}}$ R_{SI}1.3	.1 ACH	65%	YES	$3,121.00
10	Proposed Lethbridge Measures With Double Glazing	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 $\frac{R_{SI}\ 3.5}{R7.5^{*}}$ R_{SI}1.3	.1 ACH	65%	YES	$3,715.00
11	As Above Plus Heat Recovery	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 $\frac{R_{SI}\ 3.5}{R7.5^{*}}$ R_{SI}1.3	.1 ACH	65%	YES	$4,915.00
11A	As No. 11 Main Windows South	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 $\frac{R_{SI}\ 3.5}{R7.5^{*}}$ R_{SI}1.3	.1 ACH	65%	YES	$4,915.00
11B	As No. 11 Main Windows West	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 $\frac{R_{SI}\ 3.5}{R7.5^{*}}$ R_{SI}1.3	.1 ACH	65%	YES	$4,915.00
11C	As No. 11 Main Windows North	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 R_{SI} 3.5	.1 ACH	65%	YES	$4,915.00
11D	As No. 11 Main Windows East	R28 R_{SI} 4.9	R34 R_{SI} 6.0	R20 R_{SI} 3.5	.1 ACH	65%	YES	$4,915.00
12	Super Insulated House Including Heat Recovery	R48	R60	R_{40} Above Grade R_{20} Below Grade R_{10} Below Floor	.1 ACH	65%	YES	$11,359.00

NOTE: The house conservation strategy number corresponds to the computer analysis run number.
The model house is a 100 square meter bungalow.
The "Hotcan" Program does not consider wind speed and frequency.

* Below Floor

c) Energy Consumption Analysis

The National Research Council, Division of Building Research, has recently developed a computer program named HOTCAN, which can predict the following information regarding the energy performance of a house:

i) Percentage seasonal heat loss from each major building component.

ii) The internal gain contribution to monthly/yearly space heating requirements.

iii) The solar heat contribution to monthly/yearly space heating requirements.

iv) The auxilliary heat energy required on a monthly/yearly basis.

The required inputs to the program are:

i) Site specific environmental data for long term normals of sunshine, air and ground temperatures and design temperature. Wind speed and frequency is not a required input to this program.

ii) Base electrical energy loads for the home (the average electrical consumption for Lethbridge).

iii) Base domestic hot water energy consumption (the average for Lethbridge).

iv) Building parameters; R values, areas, glazing orientation, air tightness and heat recovery efficiency.

The HOTCAN program was used to compare each of the conservation strategies listed above, for the model 100 square metre bungalow, in the Lethbridge environment.

In order to determine the accuracy of the HOTCAN program, the Alberta Building Code model house was computer analyzed. The auxilliary heating requirement for one year was compared to the average energy consumption of 14 Lethbridge houses in this 100 square metre size and style. The variation between actual average energy consumption and computer analyzed energy consumption was 9%. Considering the wide variety of influencing factors, this variation was not considered significant.

Computer runs for each energy conservation strategy appear in Appendix B2, "HOTCAN 2.0 Computer Runs". Note that the final calculated auxilliary energy requirement (in the computer runs) must be divided by the seasonal furnace efficiency to obtain actual natural gas consumption per season. Also, note that the added value of a night setback thermostat for energy savings was analyzed by adjusting the furnace efficiency rating.

The values obtained from computer Runs #1-7 and Run #12 represent each of the conservation strategies outlined above. Computer Runs #8-11 and #11A-11D were developed from the following Benefit-Cost Analysis and Solar Orientation Analysis.

A summary of the yearly energy consumption for each housing strategy appears on the cost-benefit chart following the next section.

d) Benefit-Cost Analysis

Benefit-cost analysis is a method by which all benefits, present and future, are compared with all costs, present and future, to determine the desirability of a proposed investment. For the purpose of this analysis, benefits are considered to be the energy dollars saved as a result of building to higher standards, and costs are the incremental cost of building beyond the current Alberta Building Code requirements, at the time of construction.

To determine the final benefit-cost ratio, the following calculation was used:

$$\text{B-C Ratio} = \frac{\text{Present Value of Energy Savings over 20 years}}{\text{Incremental Construction Costs}} *$$

where

Present Value = The discounting of future energy savings to reflect future savings in today's dollars.

Energy Saving = The expected energy (gigajoules) saved multiplied by the forecast future prices (20 years) of Natural Gas in Alberta, as supplied by the National Energy Program, update 82. See Appendix 2D "Energy Costs and Projections".

Incremental Cost = The difference between the proposed construction and the Alberta Building Code. (See Table 3.1).

* The value of future energy savings are discounted by 12% yearly in order to arrive at a present value.

Benefit-cost ratios are a simple way of determining the ranking of alternative conservation strategies.

Energy price projections for 20 years were obtained from the Federal Department of Energy (See appendix B3). Although these projections are subject to change, a twenty year period was used for analysis. A benefit-cost ratio of 1/1 represents a 20 year payback, while a ratio greater than 1/1 has a shorter payback period and conversely, a ratio of less than 1/1 has a longer payback period.

The benefit-cost ratio for each conservation strategy is listed in the following Table 3.2.

TABLE 3.2

BENEFIT-COST ANALYSIS SUMMARY

RUN #/ Model #	HOUSE DESCRIPTION	YEARLY SPACE HEATING ENERGY CONSUMPTION GJ 1 yr	GJ SAVED PER YEAR	BENEFIT-COST RATIO AT 20 yrs	SAVINGS 10 yrs	SAVINGS 20 yrs	INCREMENTAL COST	PAYBACK PERIOD	RANK
1	Alberta Housing Code - Furnace efficiency 55%	124.65	-	-	-	-	-	-	-
2	Alberta Housing Code Air Tightness, Mech ventilation Increase furnace efficiency to 65%	105.48	19.17	.57/1	$ 572	$1,005	$ 1,762	49 yrs	10
3	Run 2 plus Heat Exchanger at 70% Recovery Rate	75.54	49.11	.87/1	$1,466	$2,573	$ 2,962	24 yrs	9
4	Upgrade walls to Rsl 3.52 Upgrade basement to Rsl 2.11 Mech. Vent, furnace at 65%	73.14	51.51	1.03/1	$1,538	$2,699	$ 2,615	19 yrs 2 months	2
5	Run 4 plus Heat Exchanger at 70% Recovery Rate	46.20	78.45	1.08/1	$2,343	$4,111	$ 3,815	18 yrs 2 months	1
6	Sask HELP home Mech. Vent	56.77	67.88	.91/1	$2,026	$3,556	$ 3,905	22 yrs 9 months	8
7	Run 6 plus Heat Exchanger at 70% Recovery Rate	30.17	94.48	.97/1	$2,821	$4,951	$ 5,105	20 yrs 9 months	5
8	Sask HELP home - less Rsl[1] in ceiling Rsl[1.3] in floor perimeter Mech. Vent	54.37	70.28	.94/1	$2,099	$3,683	$ 3,921	21 yrs 9 months	7
9	Run 8 plus Heat Exchanger at 70% Recovery Rate	27.80	96.85	.99/1	$2,892	$5,075	$ 5,121	20 yrs 3 months	4
10	Double Glazing; Rsl[6] Ceiling; Rsl[1.3] in floor perimeter; with mechanical ventilation	57.38	67.27	.93/1	$2,009	$3,525	$ 3,715	21 yrs 6 months	6
11	Run 10 Plus Heat Exchanger at 70% Recovery Rate	30.85	93.80	1.00/1	$2,801	$4,915	$ 4,915	20 yrs	3
11A	Main Windows South - Double Glazing	27.54	97.11	1.04/1	$2,900	$5,089	$ 4,915	19 yrs 1 month	
	S 6.54 m sq / N 1.39 m^2 / E 1.36 m^2 / W 1.86 m^2								
11B	Main Windows West	31.69	92.96	.99/1	$2,776	$4,871	$ 4,915	20 yrs 3 months	
	S 1.36 m sq / N 1.86 m^2 / E 1.39 m^2 / W 6.54 m^2								
11C	Main Windows North	33.66	90.99	.97/1	$2,717	$4,768	$ 4,915	20 yrs 10 months	
	S 1.39 m sq / N 6/54 m^2 / E 1.86 m^2 / W 1.36 m^2								
11D	Main Windows East	30.98	93.67	1.00/1	$2,797	$4,908	$ 4,915	20 yrs	
	S 1.86 m sq / N 1.36 m^2 / E 6.54 m^2 / W 1.39 m^2								
12	Super Insulated House	15.38	109.27	.50/1	$3,263	$5,726	$11,359	75 yrs	11

e) Residential Conservation Parameters for Lethbridge

Once the energy analysis of each of the above conservation strategies (Computer Runs #1-7 and Run #12) was complete, and the corresponding benefit-cost ratio was calculated, the results were analyzed to determine which conservation measure should be adjusted for the specific situation of the City of Lethbridge.

In view of the one time opportunity to include certain conservation measures in a new structure, compared to other conservation measures which can be added on "RETROFIT" to a structure in the future, it was concluded that greater emphasis should be placed on fixed building components which would be difficult or impossible to change in the future.

Analyzing computer Runs #4-7 indicates that the greatest seasonal heat loss associated with these conservation strategies is through above grade walls and the perimeter of the basement floor. Each of these building components are very costly or impossible to upgrade in the future.

Comparatively, seasonal heat loss through ceilings and triple glazing versus double glazing areas was relatively small. Attic insulation can be upgraded in the future, and windows, can be upgraded with thermal shutters as these technologies become available.

Heat exchangers, which are a signficiant proportion of the incremental cost, can be added in the future, if an appropriate mechanical ventilation system is installed during initial construction.

Consequently, these changes were applied to the model house to determine energy performance, incremental cost and cost benefit ratios.

These various conservation strategy changes were analyzed for energy consumption in computer Runs #8-11 and the benefit-cost ratios are described in the preceeding benefit-cost Table 3.2 on page 3-12.

It was concluded that the best conservation strategy for the City of Lethbridge is that described as House Model No. 11 on the Benefit-Cost Analysis Summary Table 3.2. The main features are described below.

LETHBRIDGE MODEL HOME

	Insulation Level
Ceiling	RSI 6 (R35)
Wall	RSI 4.9 (R28)
Basement	RSI 3.5 (R20)
Foundation Perimeter	RSI 1.3 (R8)

Other features include air tightness, double glazed windows, mechanical ventilation, and heat exchangers.

Although this model ranks number 3 in terms of cost benefit ratio, it is considered the best strategy because high quality insulation has been included in above grade walls and the perimeter of the basement floor, both of which contribute to a large percentage of seasonal heat loss, and both of which are difficult to upgrade in the future.

House Model No. 10 is the same as House Model No. 11, except that a heat recovery system is not included. Note that the incremental cost for House Model No. 10 is less than the incremental capital cost for House Model No. 5, which has the best overall cost-benefit rank.

Consequently, House Model No. 10 is a good present description of energy conservation parameters for the City of Lethbridge. This House Model No. 10 can be upgraded to the Model No. 11 by the simple addition of an air-to-air heat recovery system. Also, more attic insulation and window insulation can be added in the future, should the price of energy then warrant increased conservation measures.

For a description of the building parameters associated with these computer models see the Table 3.1 on page 3-4, "Housing Conservation Strategies ...".

The building guidelines for Lethbridge have been developed from House Model No. 10 and 11.

f) Solar Orientation

All previous analysis was conducted assuming equally oriented window glazings, with 25% of the window area facing in each cardinal direction.

The glazing area for the model house is 11.15 square metres. This window area represents 11% of the above grade floor area.

In order to determine the energy savings associated with directional orientation, the glazing area was redistributed so that 6.69 square metres (60% of the glazing) was on one side of the structure, with the remaining 40% dispersed among each of the remaining three facades.

The Lethbridge energy conserving model house (#11) was then rotated in each of the four cardinal directions, north, east, west and south.

The auxilliary energy requirements for each directional orientation is analyzed in computer runs 11A - 11D and benefit-cost ratios are described in the Table 3.2 on page 3-11.

The least auxilliary energy consumption was required for the south window exposure (27.54 GJ per year) compared to the greatest requirement for the northern window exposure (33.66 GJ per year). There is a 22% increase in the demand for auxilliary energy comparing north window to south window exposure.

However, because of the low total demand for auxilliary energy, this 22% increase represents only 6.12 gigajoules savings per year, at a present cost of $21.00, and a future cost of $105 in the year 2001 (according to National Energy Board price projections). Present technology for utilizing passive solar gain in suburban housing is limited to southern exposed glass (the surface area of which should be limited to no more than 8% of the serviced floor area) and appropriate overhangs. In order to improve the solar contribution to space heating, new technologies for window shuttering, low temperature thermal storage and active solar systems will be necessary. None of these new technologies are refined or cost effective enough to be considered at the present time.

In conclusion, the present solar contribution to a low energy structure is not a significant influence on subdivision layout when compared to transportation and land use planning as developed earlier in this report.

3.1.3 Conclusion

Energy efficient housing is an emerging concept and technology which provides many qualities, including:

i) Greater personal thermal comfort and control over the interior environment.

ii) Reduced energy requirements and costs.

iii) The benefit of an expenditure which has a payback, compared to many expenditures which have none.

iv) Greater resale value compared to conventional housing.

v) Greater security from energy shortages.

vi) Adaptibility to new high efficiency supply alternatives.

This study indicates that in Lethbridge the payback period for the suggested conservation strategy (20 years) is relatively long compared to individual occpancy, but relatively short compared to the life of the structure.

The study also indicates that the incremental cost is modest (6.1% to 8.5% increase in capital cost), especially considering that the analysis compared the conservation strategy costs to the minimum standards of the Alberta Building Code. The cost of the base model house developed for this study was $57,670.00 in 1982.

The incremental cost of the suggested energy efficiency house for Lethbridge is $3,715, or $4,915 with a heat recovery system (which can be

optionally added in the future). This cost compares to other discretionary purchases which people make for their new homes, such as upgraded flooring, kitchen cabinets, extra floor space, brick facades and similar items. Benefit-cost ratios aside (after all, what is the payback period for indoor plumbing) energy conservation is a new quality which can now be added to a home. This new quality has the benefits listed above, plus it adds to the energy reserves of the province and nation.

From the perspective of national interest, many justifications have been formulated to recommend subsidy for energy conservation in new and existing homes.

In view of savings associated with a more cost effective subdivision designs as described in this report, the City of Lethbridge should consider a land price reduction for those builders or individuals who meet or exceed the standard of the "Lethbridge Model".

3.2 Guidelines For The Construction of Energy Conserving Housing In Lethbridge

These guidelines are not designed or intended to contravene existing municipal building codes or bylaws. The guidelines applied to a specific house must be checked for compliance with local codes and bylaws.

The guidelines represent the techniques which should be followed in entirety to construct an energy conserving residential structure.

3.2.1 Design and Planning

Once contractors and subtrades have built to these specifications, over a period of time, they will become "rule of thumb" applications. However,

when first building to these specifications, detailing the techniques on the construction drawings will eliminate on-site problems and facilitate easier application of the air-vapour barrier, insulation and mechanical ventilation systems.

Currently, much research is on-going to test the validity of the polyethylene method of obtaining an air-tight building envelope. Other methods do appear promising but none have been widely tested and therefore it is suggested that the current form of the Lethbridge Model incorporate sealing details based on the polyethylene air-vapour barrier method.

3.2.2 Guideline Summary

a) Air Tightness

i) The air-vapour barrier should be installed so that it provides a complete seal around the entire structure.

ii) The air-vapour barriers should be 6 mil polyethylene sheeting, caulked and sealed at all joints.

iii) Caulking materials should be non-hardening and maintain flexibility and adhesion when in contact with the polyethylene sheeting.

iv) All joints between polyethylene sheets should be made over solid backing materials.

v) The air-vapour barrier should be continuous behind partitions at walls and ceilings.

vi) The air-vapour barrier should be sealed when it terminates at doors, windows, attic hatches, receptacles or similar openings which penetrate the air-vapour barrier.

vii) Windows, doors, access doors and hatches should be weather stripped on all perimeter edges.

TABLE 3.3

ALLOWED AIR INFILTRATION OF EXTERIOR OPENINGS

Building Assembly		Maximum Air Infiltration Rate*
Windows		.77 dm^3/second/metres of sash crack
Doors	- Swing Type	6.35 dm^3/second/m^2 of door area
	- Sliding	2.5 dm^3/second/m^2 of door area

* This represents a maximum air infiltration rate in conformance with ASTM E283-73 "Standard Method of Testing for Air Leakage Through Exterior Windows, Curtain Walls".

b) Insulation

The following insulation levels are recommended minimum standards. (R values are nominal and do not include facing materials or air films).

Building Assembly	R_{SI} Value	R Value
Basement walls to floor	3.5	20.0
Basement floor perimeter to 1.2m inside foundation footings	1.3	7.5
Footing insulation to 1.2m outside foundation wall, for foundation footings less than 1.5m below grade	1.3	7.5
Above grade walls	4.6	26.5
Ceiling	6.0	34.0
Floors over unheated spaces	4.9	28.0
Slab on grade, perimeter insulation	3.5	20.0
Doors	1.76	10.0

Windows - double glazed, 13.0 mm airspace between glazings.

c) Mechanical Ventilation

In air-tight structures mechanical ventilation is essential to ensure that an adequate supply of fresh air is available. If mechanical ventilation is not provided, or if the system is blocked, the resultant poor air quality may pose problems for the occupants' health. The mechanical ventilation system should be designed to accommodate an air-to-air heat exchanger.

Minimum requirements for a mechanical ventilation system without a heat exchanger are:

i) All exhaust locations, such as bathrooms, kitchen and laundry should be ducted down through walls and floors to one exhaust fan located in the basement or mechanical area of the house. The exhaust fan is to be ducted to the outside, a minimum of 0.6 metres above grade. The exhaust opening to the exterior should be screened and rain capped with a closure flap.

ii) Fresh air is to be introduced to the structure through an equivalent fan, drawing air from an intake opening not less than 1.8 metres horizontally from the exhaust port described above in i). Fresh air through the intake fan should be directed into the return air side of the forced air furnace system. The fresh air intake duct should be insulated, vapour barriered and equipped with an adjustable damper to control the incoming air volume.

iii) Each fan should have a free air capability of moving half the air volume of the entire house every hour.

iv) Fans should be jointly controlled with a speed control switch which governs continuous low speed operation (winter months), and by high speed override switches located in each of the exhaust locations in the house.

v) Duct sizes for the mechanical ventilation collection ducts should be 127.0 mm runs to each bathroom, and 152 mm runs to kitchen and laundry areas. Duct size between the fans and exterior walls should be a minimum 178 mm diameter. The incoming fresh air duct should be covered with insulation and a vapour barrier.

vi) Heat exchangers can be added to the mechanical ventilation system. Most heat exchangers come equipped with fans and controls as described above.

A floor drain should be provided in close proximity to the heat exchanger.

d) Heating Equipment

i) A fresh air duct is required for combustion equipment, as stipulated by the Provincial Gas Code.

ii) Combustion forced air furnaces should be equipped with electronic ignitions and automatic flue dampers.

iii) Multiple set back thermostats should be used to control applicable heating systems.

iv) Furnaces should be sized no greater than 30% larger than the design heating load.

v) Fire places require glass or metal doors with tight sealing dampers. Woodstoves must be airtight. Fresh air feeds are required for all wood combustion devices.

e) Housing Orientation and Glazing Areas

The site orientation of a house influences energy performance and comfort due to the directional orientation of the main glazing areas.

i) Maximum glazing area should not exceed 12% of the total building area served by the glazing.

ii) Optimum energy performance and passive solar gain results from major glazing areas facing within 30° east or west of south.

iii) The maximum glazing area facing south should not exceed 8% of the above ground floor area, unless provisions are made to accommodate the excess heat from solar gain.

iv) The following table lists the overhang width necessary to shade south windows from summer sun, and allow winter sun penetration.

Window Depth From Bottom of Lintel	Overhang Width
0.9 m	0.6 m
1.5 m	0.9 m
2.1 m	1.2 m

v) If major glazing areas face east or west, summer shade control should be provided with awnings, vegetation, reflective films or shades.

vi) Major glazing areas should not face north.

f) Energy Conserving House Construction Practices

The following diagrams illustrate techniques for achieving air tightness, higher insulation levels and mechanical ventilation in an energy conserving house.

These diagrams are grouped according to each major subtrade involved in the construction of a residential structure.

The diagrams have been adapted from the following publications:

Air-Vapour Barriers; D. Eyre, D. Jennings, Saskatchewan Research Council, 3rd Edition March, 1982.

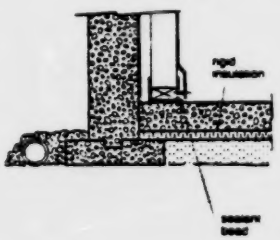
Energy Efficient Housing - A Prairie Approach; National Research Council, Saskatoon, Office of Energy Conservation, Saskatchewan Mineral Resources: September, 1981.

The techniques illustrated in the following section do not represent all acceptable building alternatives, nor do they cover all problem areas that will be encountered during construction practice.

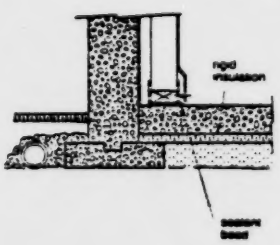
g) Basement and Floor System

i) Perimeter Insulation

The perimeter of the basement floor looses a large amount of heat over a heating season. 38 mm of rigid insulation should be applied to 1.2 m inside the perimeter, before pouring the basement floor slab.

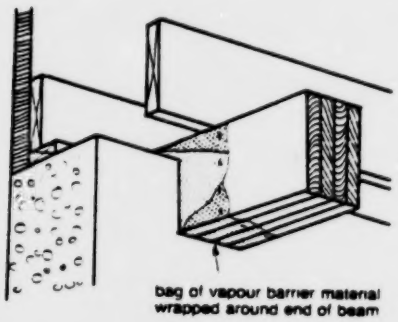


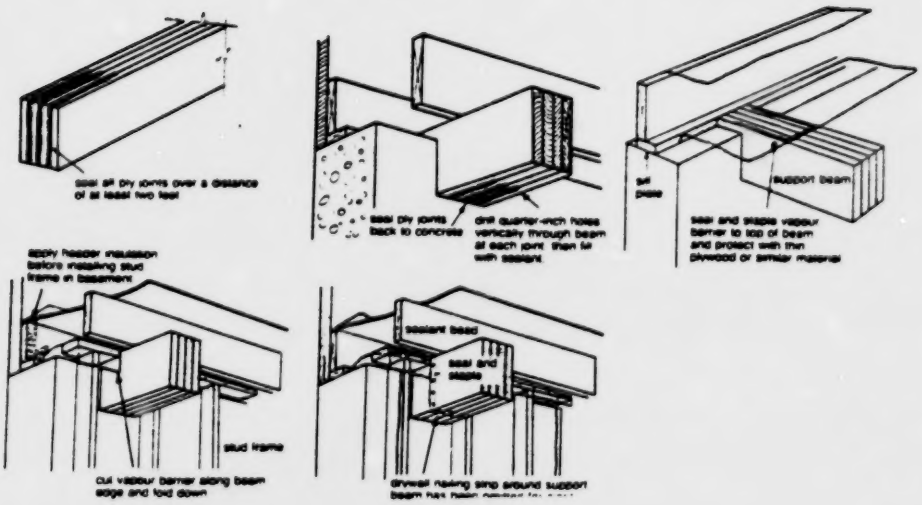
For shallow foundation footings less than 1.5m below grade, an additional 38mm of rigid insulation must be applied outside the foundation wall, above the footings to a distance of 1.2 m from the foundation wall.



ii) Floor Support Beams

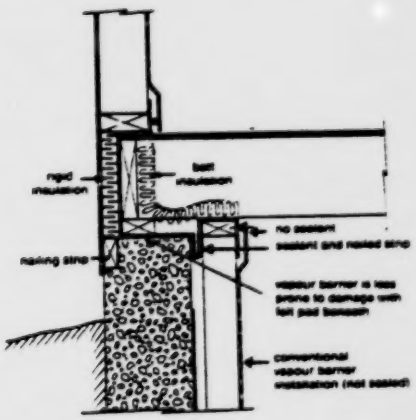
The area where the beam penetrates the wood or concrete wall creates a path for air leakage. The accompanying diagrams illustrate two different techniques to seal the beam against leakage.

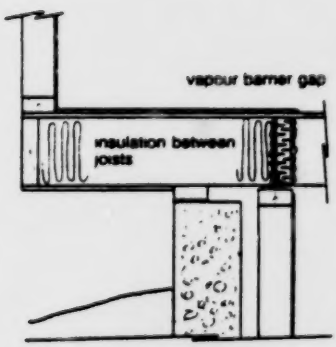


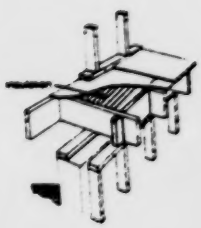


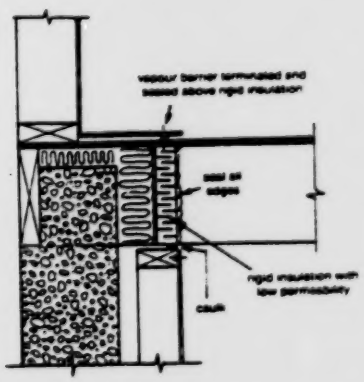
iii) Air Tightness and Insulation of Floor Systems

The exposed floor header and joist system is a common area of air infiltration. The accompanying diagrams illustrate techniques of wrapping a continuous air-vapour barrier around the floor system and maintaining adequate insulation levels.





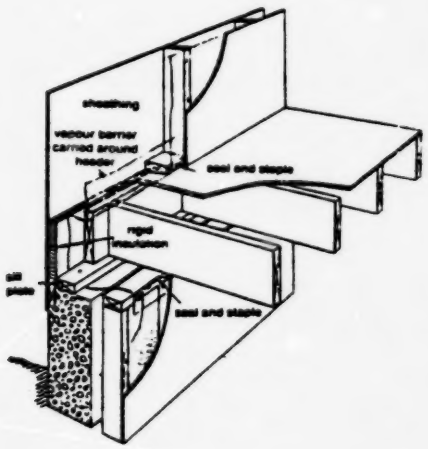


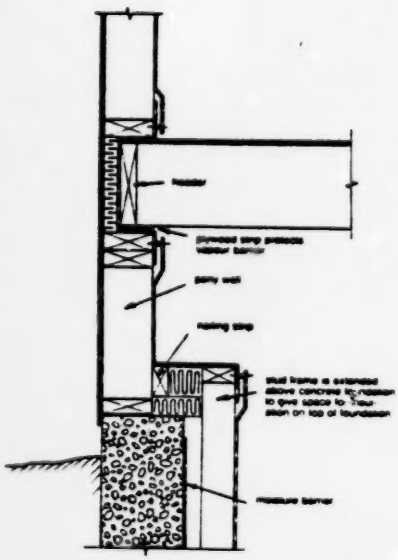


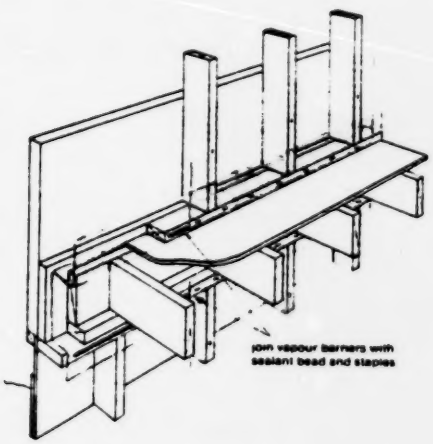
h) Framing

i) Exterior Wall Sole Plates and Floor Systems

Exterior walls should be placed carefully on top of the plastic wrapped around the floor header system. The same principles apply to first and second wall/floor interfaces and to pony walls.

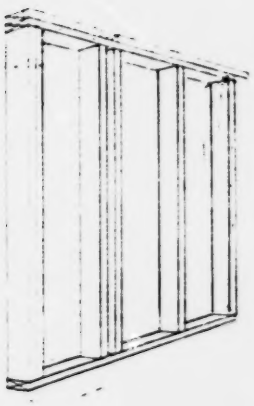


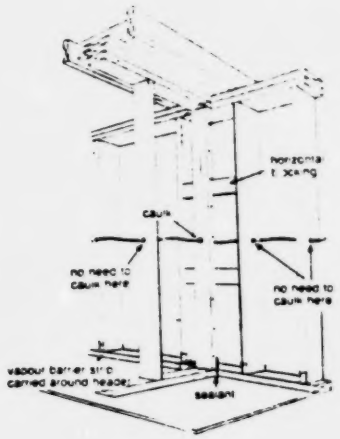


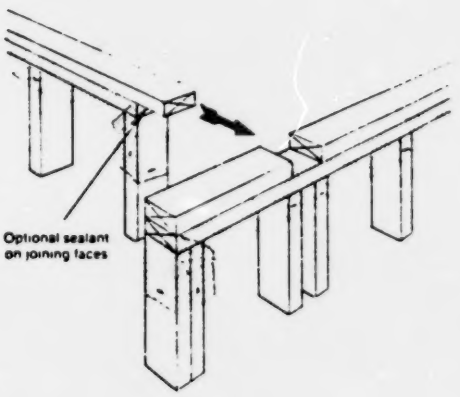


ii) Polyetheylene Strips On Exterior Partitions

In order for the air-vapour barrier to be continuous, strips of 6 mil polyethylene must be applied behind all exterior wall and ceiling partitions. Care should be exercised so that these strips are not damaged during subsequent construction.



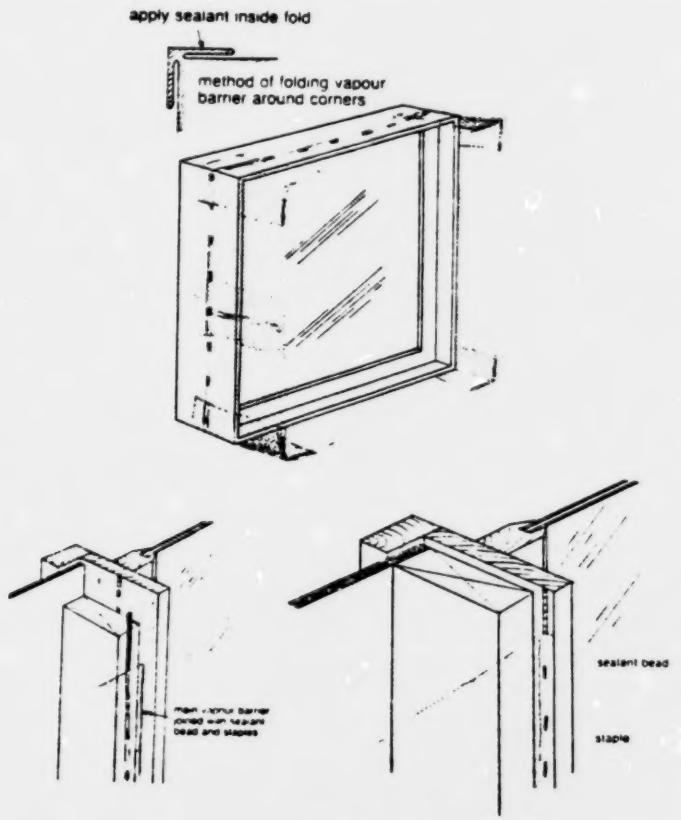




iii) Door and Window Preparation

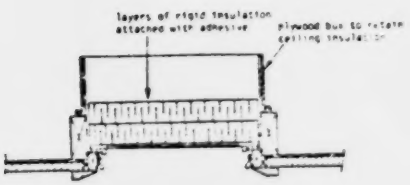
Both doors and windows can be prepared before installation, so that air tightness can be maintained between the frame and the rough opening. A 6 mil strip of polyethylene should be caulked and stapled to the window. Folds should be left at the corners in order to allow the plastic to conform to the rough opening without tearing or cutting.

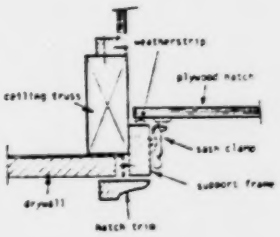
A less desirable technique is to seal the final vapour barrier against the window frame after installation of the window is complete (see right diagram).

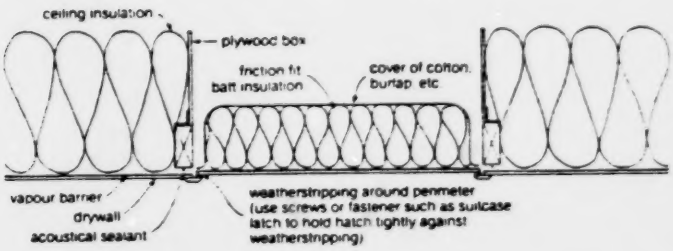


iv) Attic Hatch

The attic hatch should be moved to the exterior gable above the ceiling insulation, or constructed in accordance with the accompanying alternatives.

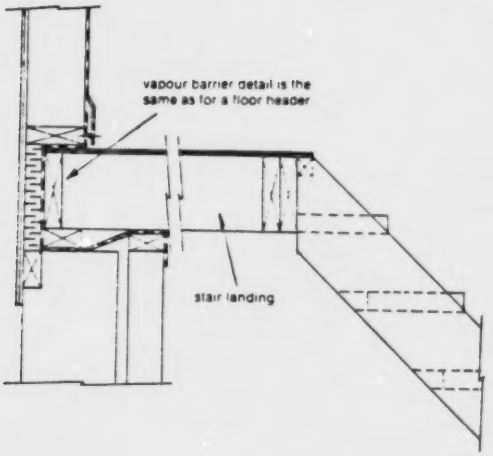


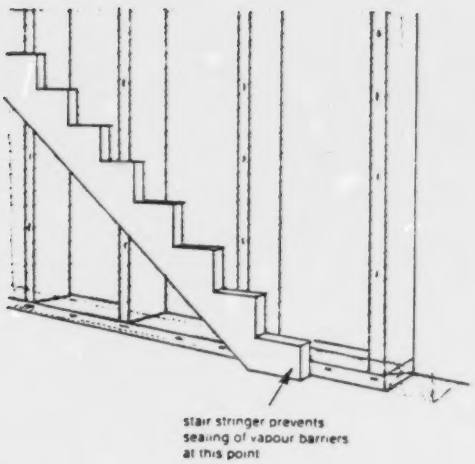



ceiling insulation
plywood box
friction fit batt insulation
cover of cotton, burlap etc
vapour barrier
drywall
acoustical sealant
weatherstripping around perimeter (use screws or fastener such as suitcase latch to hold hatch tightly against weatherstripping)

v) Stairs Adjacent to Exterior Walls

Where stairs are adjacent to exterior walls, care must be taken so that the air-vapour barrier, insulation and drywall are fully installed before final installation of the stair system.





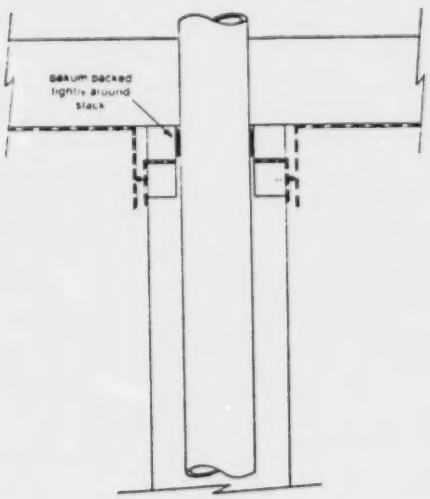
vi) Blocking

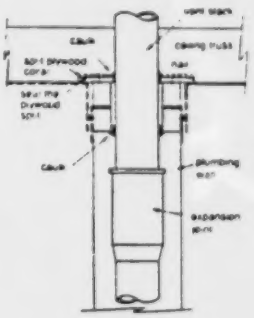
All blocking for cabinets, towel bars, soap dishes and drywall application should be in place prior to installation of the air-vapour barrier.

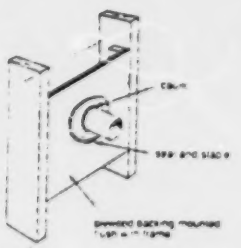
i) Plumbing

i) Stacks and Vents

All plumbing stacks and vents should penetrate the air-vapour barrier envelope through round holes in solid backing materials and be sealed with caulking against air infiltration.



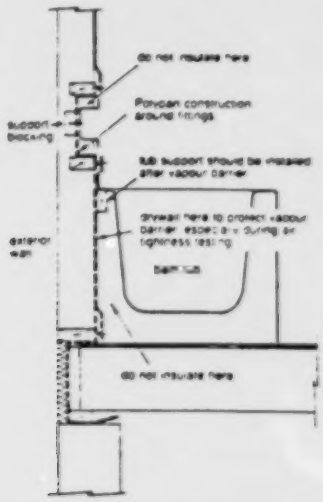




ii) Tubs and Shower Enclosures

Exterior walls adjacent to tubs and showers should be prepared with insulation and air-vapour barriers before final application of

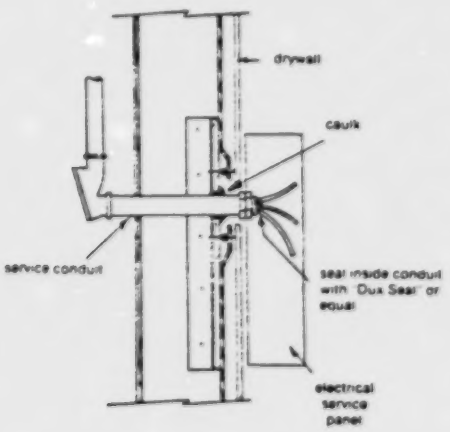
the tub or shower enclosure. Appropriate right or left hand tubs should be chosen to keep water piping away from exterior walls.



j) Electrical

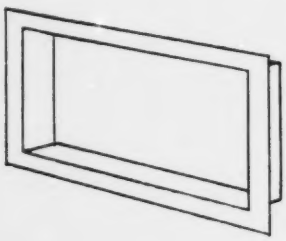
i) Electric Service Panels

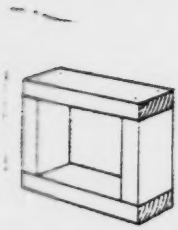
Electric service panels should be installed on interior partition walls where possible to avoid puncturing the air-vapour barrier with wire runs. Where the service panel must be applied to an exterior wall, the insulation, air-vapour barrier and drywall should be properly placed first.

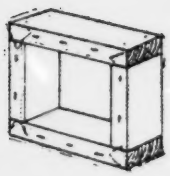


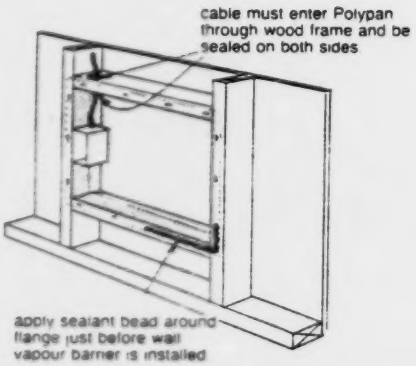
ii) Exterior Wall Receptacles

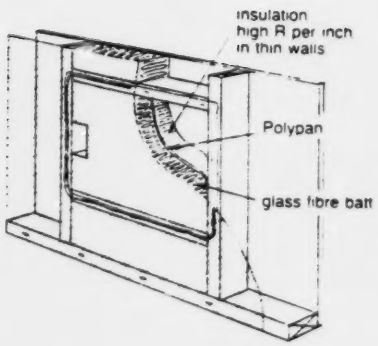
Receptacles must be placed inside appropriate "polypans" or "polyhats" before fixing to wall studs or wiring.





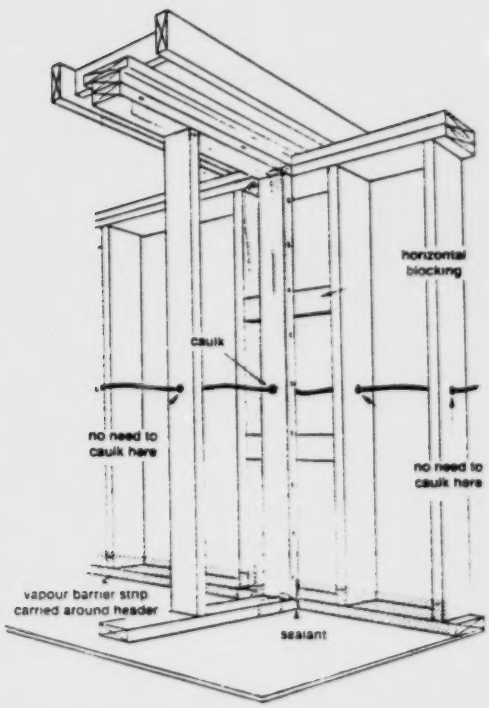



cable must enter Polypan through wood frame and be sealed on both sides
apply sealant bead around flange just before wall vapour barrier is installed



iii) Wire Runs

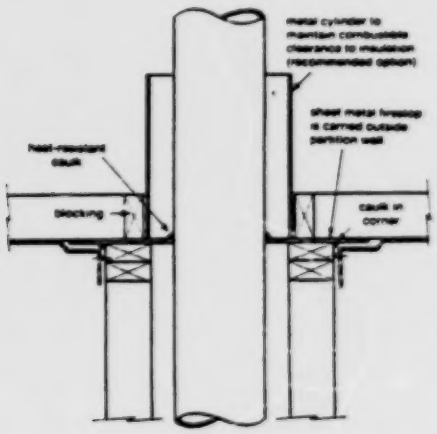
Where possible, wire runs should be in interior partition walls and floors. Where wire runs penetrate to the exterior, the holes through studs or plates must be caulked.



k) Mechanical

i) Heating System - Chimney

The chimney penetration through the ceiling should be sealed with heat resistant caulking to the firestop, which in turn should be sealed to the air vapour barier at its outer perimeter.



ii) Heating System - Combustion Air

A fresh air duct is required for combustion equipment as stipulated in the provincial gas code.

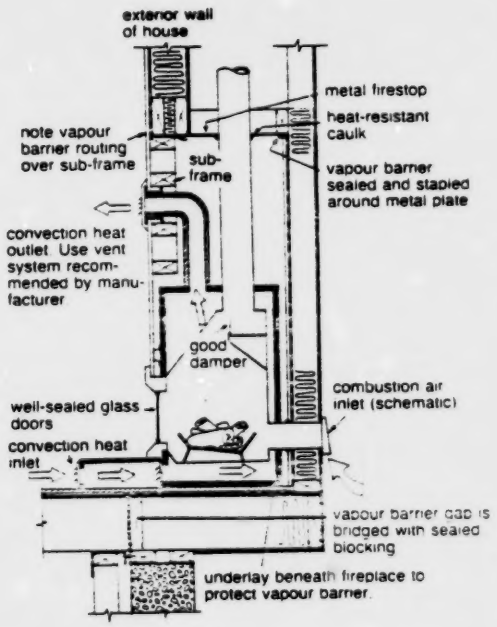
iii) Heating System - Return Air Registers

In an air tight structure, return air (R/A) registers should be situated at the top of walls instead of the baseboard level, in

order to destratify and circulate internal heat. The best placement of R/A registers is in solar gain rooms or rooms containing wood burning appliances in order to circulate this heat. No R/A or S/A (supply air) ducts should be placed outside the air-vapour barrier.

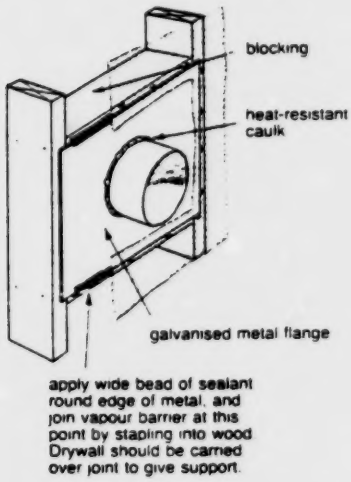
iv) Heating System - Wood Burning Devices

Fireplaces with glass or metal doors and tight flue dampers should be installed. Woodstoves should be air tight. All wood burning devices should be supplied with their own fresh air supply.


exterior wall of house
metal firestop
heat-resistant caulk
note vapour barrier routing over sub-frame
sub-frame
vapour barrier sealed and stapled around metal plate
convection heat outlet. Use vent system recommended by manufacturer
good damper
combustion air inlet (schematic)
well-sealed glass doors
convection heat inlet
vapour barrier gap is bridged with sealed blocking
underlay beneath fireplace to protect vapour barrier

v) Heating System - Fresh Air Openings

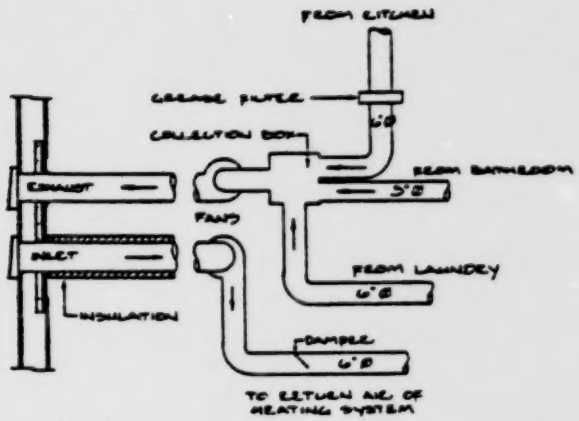
Fresh air openings through basement or above grade walls should be prepared for air tightness.


blocking
heat-resistant caulk
galvanised metal flange
apply wide bead of sealant round edge of metal, and join vapour barrier at this point by stapling into wood. Drywall should be carried over joint to give support.

l) Mechanical Ventilation For Exhaust and Fresh Air Requirements

i) Ducting

All exhaust requirements should be ducted through wall cavities (76 mm x 254.0 mm galvanized) and floors (127.0 mm galvanized round) to a central collection box in the basement or mechanical room.



ii) Exhaust Fan

An exhaust fan should connect from the collection box to the outside or through a heat exchanger to the outside, duct sizes should be a minimum of 178 mm diameter between the fan and the outside opening.

iii) Intake Fan

An intake fan wired to ensure continuous low speed operation when combustion and exhaust devices are not operating and high speed when the devices are operating, should be connected from outside to the return air plenum or through a heat exchanger to the return air plenum. The intake duct should be insulated, vapour barriered and equipped with an operable adjustment damper. Minimum duct size should be 178mm diameter. A sticker or other permanent marker should be placed on or adjacent to the intake fan and should indicate that operation of the fan is essential to ensuring adequate air quality, and that any restriction to the flow of fresh air may pose a health hazard.

iv) Fans

Fans should be sized to move a maximum of one-half of the house volume of air per hour.

v) Controls

Fans should be jointly controlled by a low speed switch for continuous operation, and high speed override switches should be provided at each of the exhaust locations in the house.

m) Air Vapour Barrier and Drywall Application

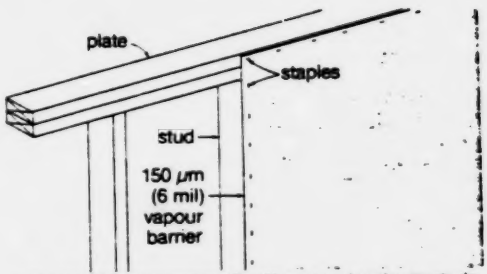
i) The air-vapour barrier should be continuous 6 mil polyethylene around the total shell of the structure, terminated at joints and openings as illustrated in preceding sections.

ii) All joints should be made against solid wood backing with a continuous bead of caulking between all overlapping joints.

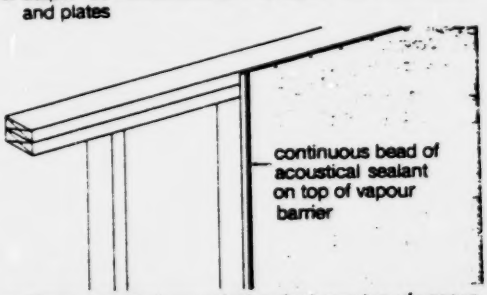
iii) All polyethylene sheets should be stapled every 150 mm or more often in difficult corners.

iv) 100 mm - 150 mm extra polyethylene should be left in corners to prevent damage from drywall application.

v) Wind loading can rip down the vapour barrier during application. In high wind situations, leave out a section of vapour barrier in the ceiling of approximately 10 m^2 dimension. Apply all other drywall and the final section only immediately before drywall application.

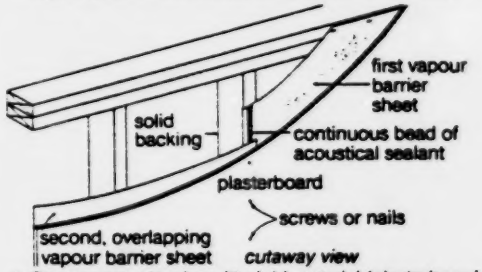


a. Staple 150 micrometre (6 mil) vapour barrier to studs and plates



b. Place a bead of acoustical sealant over top of vapour barrier, ensuring that the sealant is continuous and in line with the stud

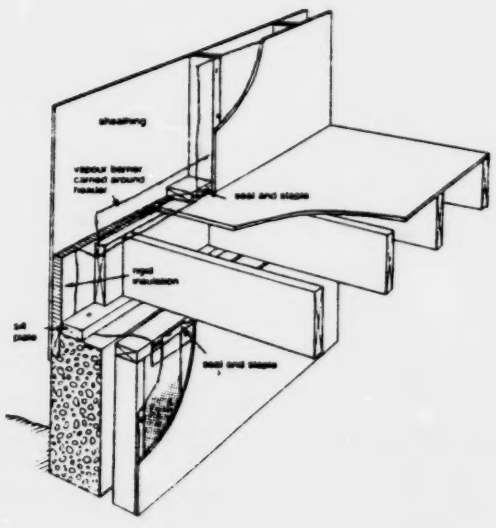
c. Overlap second vapour barrier sheet (always join the vapour barrier over a solid backing such as a stud)

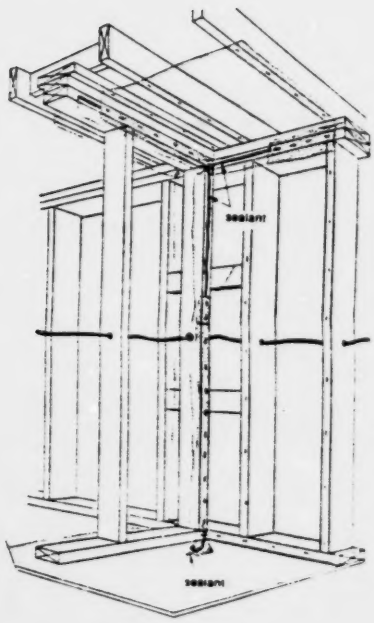


d. Cover vapour barrier with rigid material (plasterboard, wallboard, etc.)

vi) Inspect and repair any damages to the air vapour barrier before application of the drywall.

vii) Measure and pre-cut all drywall before applying over the air-vapour barrier.





3.2.3 Principles of Low Energy Residential Construction:

Reducing Energy Demand

a) Demand

Energy Demand = Energy Supplied
Reduced Demand = Reduced Supply

The largest component of residential energy consumption is for space heating, followed by energy for lights and appliances, followed by energy for domestic hot water.

The principles outlined herein address the reduction of energy demand for space heating. These principles apply equally to new housing and to renovations or additions to existing housing.

Heat is lost from a home due to two major processes:

i) Air Infiltration

Cold exterior air flowing in through cracks and openings, and warm interior air flowing out.

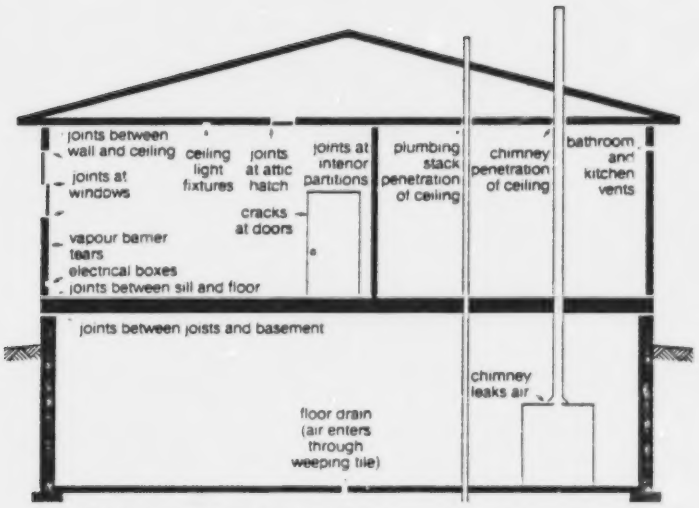
ii) Thermal Transmission or Conduction

Thermal energy, or heat flows from the warm house interior to the cold exterior through the building components; doors, windows, walls, ceilings and floors.

In order to reduce energy demand, and therefore supply requirements, each of these heat loss processes must be addressed. It is important to realize the relative contribution of each process to heat loss.

b) Air Infiltration

30% to 40% of the heat lost from a typical home is through excessive air infiltration. The following diagram illustrates typical air leakage locations in a conventional home.


joints between wall and ceiling
joints at windows
vapour barrier tears
electrical boxes
joints between sill and floor
ceiling light fixtures
joints at attic hatch
joints at interior partitions
cracks at doors
plumbing stack penetration of ceiling
chimney penetration of ceiling
bathroom and kitchen vents
joints between joists and basement
chimney leaks air
floor drain (air enters through weeping tile)

Air leakage spots in conventional housing

Excessive air infiltration creates several problems:

- drafts
- low relative humidity (static sparks in winter)
- infiltration of dust and other exterior air pollutants
- structural damage in walls and attics
- unnecessarily high energy costs

500 kilograms of air per hour flows through a typical home due to exterior air infiltration. To heat this air over the course of a heating season requires approximately 50 gigajoules of natural gas or 30-40% of the yearly heating bill.

c) Thermal Transmission

The remaining 60-70% (100 gigajoules) of the heat lost from a home is due to the conduction or transmission of heat from the warm inside to the colder exterior environment. Heat flows through any material from the warm side to the cold side. The greater the temperature difference, the greater the rate of heat flow, the less resistance or R-value, the greater the heat flow.

d) Reducing Air Infiltration

Unnecessary air infiltration can be reduced through the application of an air-vapour barrier. The air-vapour barrier is usually made from 6 mil polyethylene plastic sheeting and serves two purposes:

i) To act as a vapour barrier which prevents interior air vapour from penetrating the exterior wall or ceiling cavity and condensing to form moisture, and;

ii) To act as an air barrier to prevent air movement from the exterior to the interior of the house enclosure.

In order to accomplish a successful air-vapour barrier, all plastic joints must be caulked and sealed, and special precautions followed around all penetrations of this plastic barrier. Doors, windows and other openings must be carefully weatherstripped.

e) Reducing Transmission Losses

The rate of heat energy transmission through the shell of a structure depends on two factors:

i) The temperature difference between inside and outside.

ii) The thermal resistance or R-value of the building materials.

Temperature differences can be reduced by using a setback thermostat to lower the inside temperature when the house is unoccupied or during nightime hours.

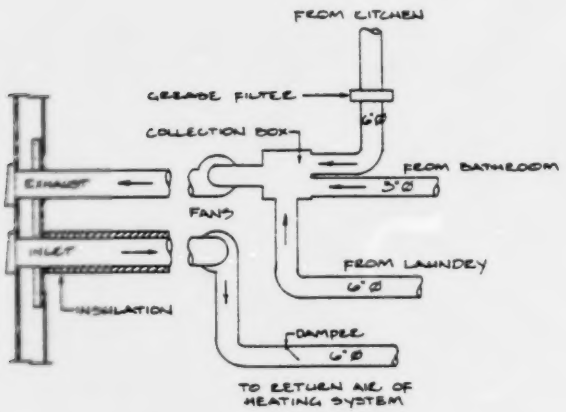
The resistance values of the building components can be increased by using higher quality or thicker insulations which are distributed evenly around the shell of the structure.

f) Mechanical Ventilation

Once a well sealed air-vapour barrier has been installed, an air tight house will not have enough natural ventilation (in winter when windows are closed) to provide fresh air for occupant comfort and humidity control. Air tight houses retain too much humidity compared to leaky houses which are too dry.

An air tight home must therefore be equipped with a mechanical ventilation system which extracts waste air from the home (from typical exhaust points such as bathrooms, kitchens and laundry areas) and introduces fresh air back into the home. The following diagram illustrates a standard mechanical ventilation system.

With a mechanical ventilation system in place, and consequently control over the incoming and exhaust air streams from the structure, an air-to-air heat exchanger can optionally be installed during construction or at some future time.

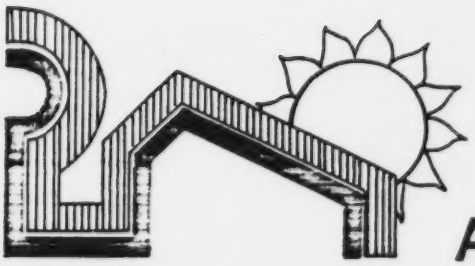


An air-to-air heat exchanger is a non mechanical device which will transfer 70-80% of the heat energy from the outgoing warm air stream to the cold incoming air stream.

g) Supply Efficiency

Once demand has been reduced and a smaller energy supply is required, further savings can be achieved by improving the efficiency of the supply system. To increase the efficiency of standard furnace systems, a furnace should have an electronic ignition (to eliminate the pilot light) and an automatic flue damper (to eliminate air leakage up the flue when the furnace is off).

Alternative sources of energy supply, such as passive solar gain or wood stoves can also be used to supplement conventional supplies in a low energy home.



Appendices

APPENDIX A1

SKYSPACE AND SHADOW DATA

SOURCE: Protecting Solar Access for Residential Development, A Guidebook for Planning Officials, U.S. Department of Housing and Urban Development

SHADOW LENGTH TABLE

These tables give the shadow length on December 21st of a one-foot pole for varying latitudes and directions and degrees of slopes. The a.m. and p.m. values correspond to 45 degrees azimuths that are used to define the day's period of usable solar radiation.

The figures are rounded off, and there may be some errors in shadow length for steeper slopes or taller buildings at **48** degrees and **50** degrees north latitude, where the rounding off error may be multiplied extensively.

LATITUDE 50°

	N			NE			E			SE			S			SW			W			NW		
Slope	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM
0%	12.8	3.3	12.8	12.8	3.3	12.8	12.8	3.3	12.8	12.8	3.3	12.8	12.8	3.3	12.8	12.8	3.3	12.8	12.8	3.3	12.8	12.8	3.3	12.8
5%	20.9	3.8	20.9	12.8	4.0	32.8	9.8	3.3	29.3	7.9	3.0	12.8	9.8	2.9	9.8	12.8	3.0	7.9	29.3	3.3	7.5		4.0	12.8
10%	-	4.5	-	12.8	4.6	-	7.3	3.3	-	5.8	2.8	12.8	7.3	2.6	7.3	12.8	2.8	5.8	-	3.3	7.3	-	4.6	12.8
15%	-	5.3	-	12.8	5.4	-	5.8	3.3	-	4.7	2.5	12.8	5.8	2.3	5.8	12.8	2.5	4.7	-	3.3	5.8	-	5.4	12.8
20%	-	9.3	-	12.8	7.2	-	4.9	3.3	-	3.9	2.3	12.8	4.9	2.0	4.9	12.8	2.3	3.9	-	3.3	4.9	-	7.2	12.8

LATITUDE 40°

	N			NE			E			SE			S			SW			W			NW		
SLOPE	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM
0%	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8	4.8	2.0	4.8
5%	5.7	2.2	5.7	4.8	2.2	6.2	4.1	2.0	5.7	3.8	1.9	4.8	4.1	1.8	4.1	4.8	1.9	3.8	5.7	2.0	4.1	6.2	2.2	4.8
10%	7.2	2.5	7.2	4.8	2.3	9.1	3.6	2.0	7.2	3.2	1.8	4.8	3.6	1.7	3.6	4.8	1.8	3.2	7.2	2.0	3.6	9.1	2.3	4.8
15%	9.6	2.9	9.6	4.8	2.6	16.6	3.2	2.0	9.1	2.8	1.7	4.8	3.2	1.6	3.2	4.8	1.7	2.8	9.6	2.0	3.2	16.6	2.6	4.8
20%	14.5	3.4	14.5	4.8	2.8	97.5	2.8	2.0	14.5	2.4	1.6	4.8	2.8	1.5	2.8	4.8	1.6	2.4	14.5	2.0	2.8	97.5	2.8	4.8

LATITUDE 45°

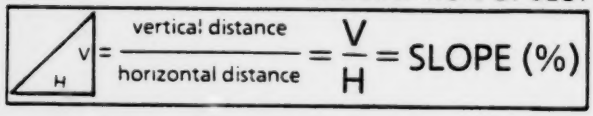
	N			NE			E			SE			S			SW			W			NW		
SLOPE	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM
0%	7.2	2.5	7.2	[illegible]	[illegible]	7.2	7.2	2.5	7.2	7.2	2.5	7.2	7.2	2.5	7.2	7.2	2.5	7.2	7.2	2.5	7.2	7.2	2.5	7.2
5%	9.6	2.9	[illegible]	[illegible]	[illegible]	11.2	5.7	2.5	9.6	5.3	2.3	7.2	5.7	2.2	5.7	7.2	2.3	5.3	9.6	2.5	5.7	11.2	2.8	7.2
10%	14.6	3.4	[illegible]	[illegible]	3.1	25.6	4.8	2.5	14.6	4.2	2.2	7.2	4.8	2.0	4.8	7.2	2.2	4.2	14.6	2.5	4.8	25.6	3.1	7.2
15%	30.3	4.1	30.3	7.2	3.5	—	4.1	2.6	30.3	3.5	2.0	7.2	4.1	1.9	4.1	7.2	2.0	3.5	30.3	2.6	4.1	—	3.5	7.2
20%	—	5.2	—	7.2	4.0	—	3.6	2.6	—	2.9	1.9	7.2	3.6	1.7	3.6	7.2	1.9	2.9	—	2.6	3.6	—	4.0	7.2

LATITUDE 48°

	N			NE			E			SE			S			SW			W			NW		
SLOPE	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM	AM	NOON	PM
0%	10.1	3.0	10.1	10.1	3.3	10.1	10.1	3.0	10.1	10.1	3.0	10.1	10.1	3.0	10.1	10.1	3.0	10.1	10.1	3.0	10.1	10.1	3.0	10.1
5%	15.8	3.5	15.8	10.1	3.3	20.5	7.5	3.0	15.8	6.7	2.7	10.1	7.5	2.6	7.5	10.1	2.7	6.7	15.8	3.0	7.5	20.5	3.3	10.1
10%	35.7	4.3	35.7	10.1	3.8	—	5.9	3.0	35.7	5.0	2.5	10.1	5.9	2.3	5.9	10.1	2.5	5.0	35.7	3.0	5.9	—	3.8	10.1
15%	—	5.4	—	10.1	4.4	—	4.9	3.0	—	4.0	2.3	10.1	4.9	2.1	4.9	10.1	2.3	4.0	—	3.0	4.9	—	4.4	10.1
20%	—	7.5	—	10.1	5.2	—	4.2	3.0	—	3.3	2.1	10.1	4.2	1.9	4.2	10.1	2.1	3.3	—	3.0	4.2	—	5.2	10.1

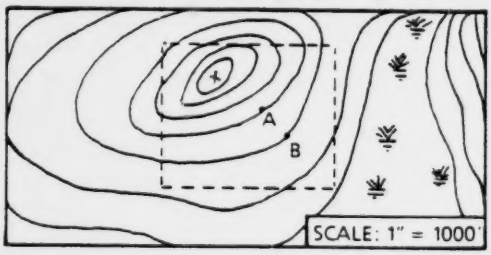
Calculating Percent Slope

CALCULATION OF SLOPE PERCENTAGE



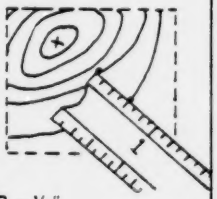
$$= \frac{\text{vertical distance}}{\text{horizontal distance}} = \frac{V}{H} = \text{SLOPE (\%)}$$

PROBLEM ► TO FIND SLOPE OF AB



$H = 500'$

STEP 1:
ESTABLISH HORIZONTAL DISTANCE



AB = ½"
since scale is 1" = 1000', then:
½ × 1000 = 500
AB = 500'

$V = 20'$

STEP 2:
ESTABLISH VERTICAL DISTANCE

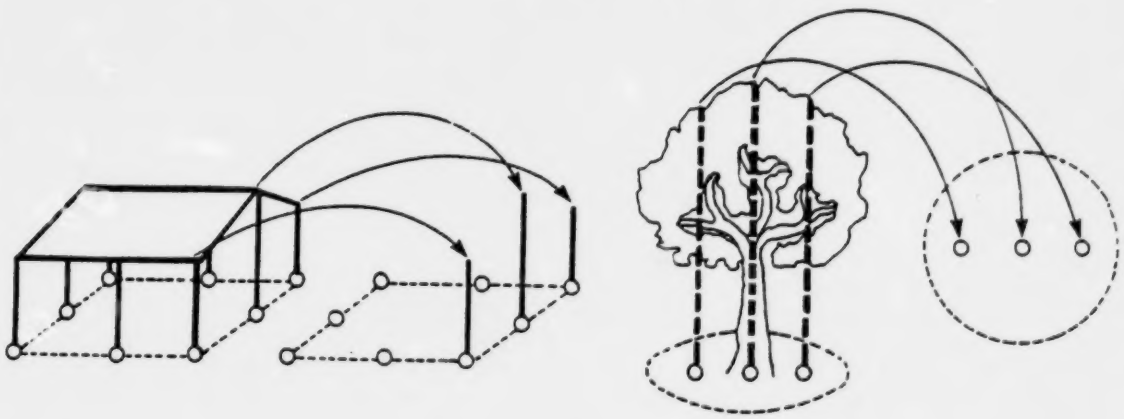
Since vertical distance equals the difference between contours, and since contour interval on this map is 20 feet, then: A – B = 740' – 720' = 20'

$$\frac{V}{H} = \frac{20'}{500'} = .04$$

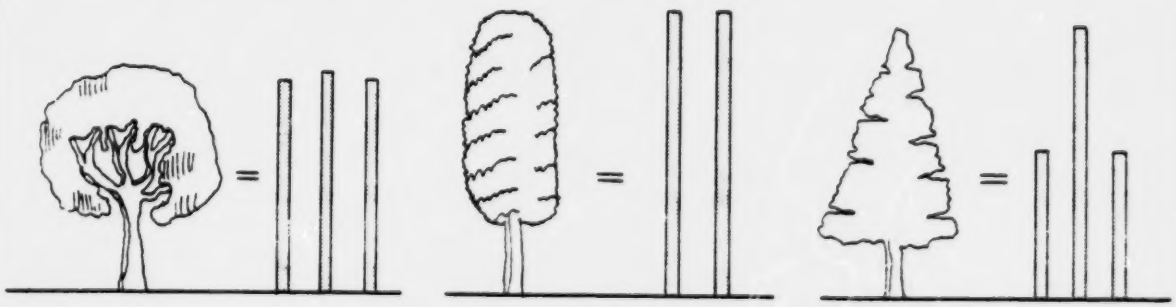
SOLUTION ► SLOPE AB = 4%

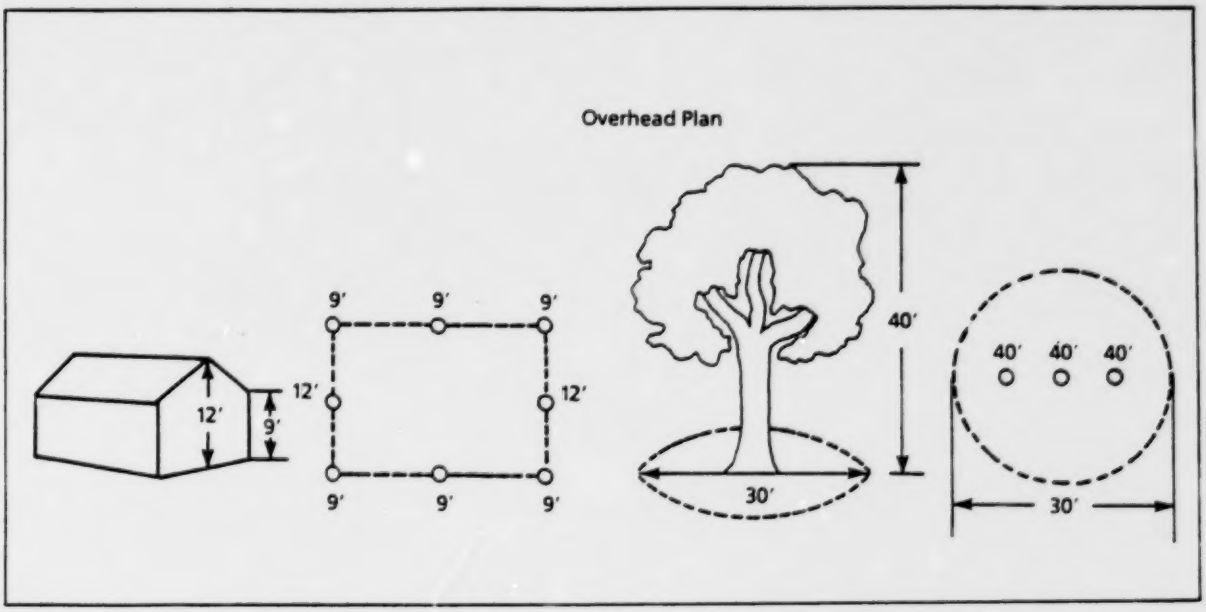
Source *The Land Book* (New Hampshire; 1976).

Representing a Building or Tree as a Set of Poles



Representing Various Tree Crown Types as Sets of Poles





Determining the Shadow Pattern for a Building or Tree
The shadow pattern for a building or tree can be determined in much the same way used to determine the pattern for a single pole. If the reader has not already seen the appropriate section (in the Planning for Solar Access chapter), refer to it before continuing here. A building or tree can be treated as a number of poles

Although trees are not shown in this example, the planner should realize that trees have depth, as buildings do. For maximum accuracy, additional poles located to the north of the tree crown "centerline" might also be considered. Trees with various common shapes also can be represented by poles of varying heights

The shadow lengths for each pole at the critical times of day are laid out, and the composite of all shadows for all poles yields the pattern for the building or tree. The following example shows how this is done for a building and tree simultaneously:

Building is 9′ high at eaves and 12′ high at peak.
Tree is 40′ high and 30′ wide.
Latitude of location is 35° north.
Land slopes to southwest at 5 percent grade.

Step 1. Draw an overhead plan of the building and tree using a series of poles.

Step 2. From the appropriate table (Page A1) (in this case for 50 degrees), find the shadow length values:

a.m. - 9·8 noon - 2·9 p.m. - 9·8

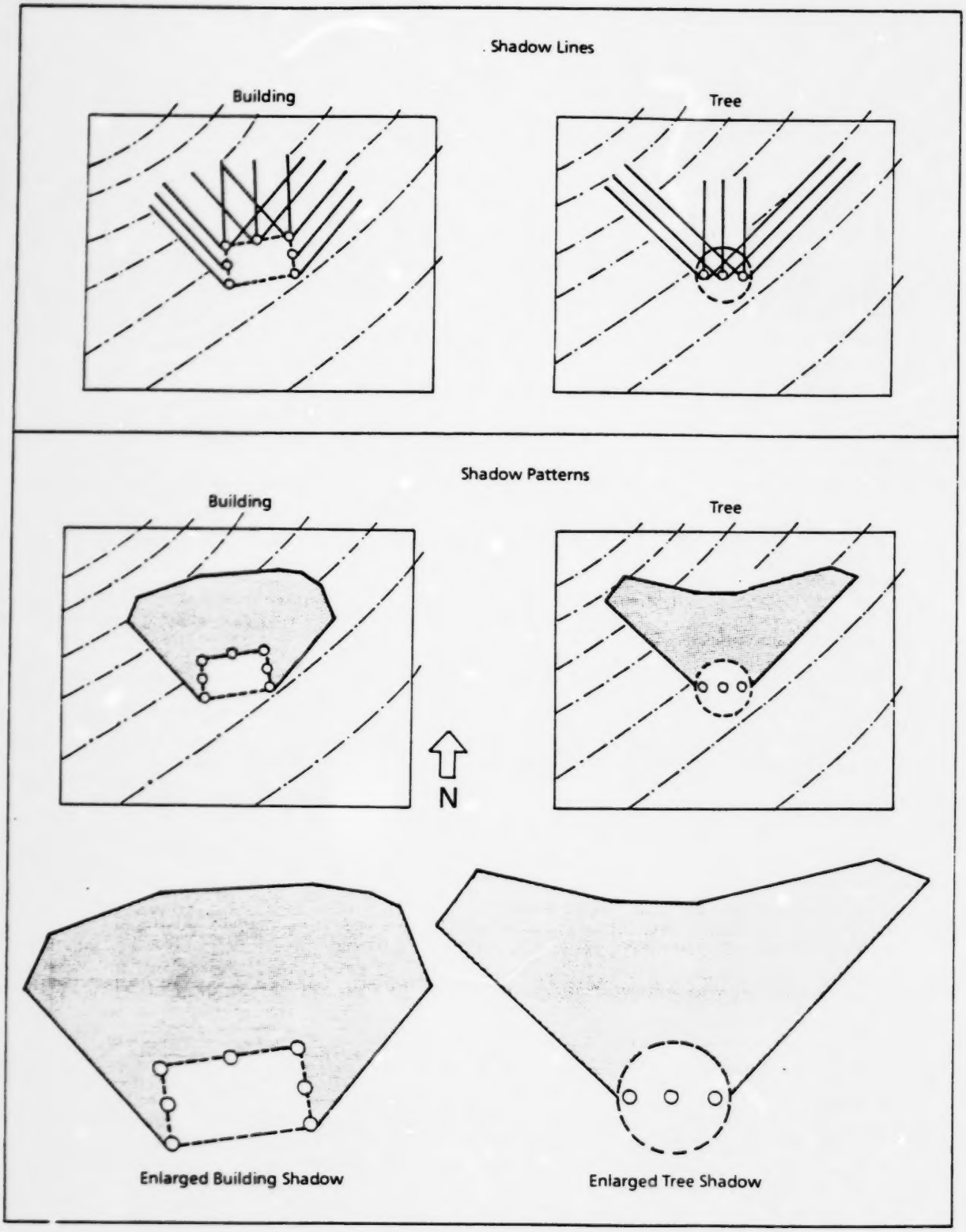
Multiply the ratios times the height of the poles used in the building and tree examples.

Figure 81. Shadow Length Table
for 9′, 12′, and 40′ Poles at 50° N. Latitude

	Height of Pole	Shadow Length A.M.	Noon	P.M.
Building	9′	88	26	88
	12′	118	35	118
Tree	40′	392	116	392

Step 3. Scale the shadow lengths out on the overhead views of the buildings and tree. The boundaries of the skyspace in this case are 45 degrees and so the a.m. and p.m. shadow lengths are laid out at 45 degrees east and west of north. (In a situation where another skyspace angle is used, like 50 degrees, this angle should be used in the shadow pattern.)

Step 4. Connect the end points of the shadow lines. The resulting figures approximate the area of ground shaded by the building and tree between the hours of the morning and afternoon that correspond to the 45 degree azimuths


Shadow Lines
Building
Tree
Shadow Patterns
Building
Tree
N
Enlarged Building Shadow
Enlarged Tree Shadow

Shadow Length Formulas

The shadow length charts are useful for most communities but are slightly inaccurate as a result of "rounding-off" errors and the fact that most communities do not lie directly on an exact latitude shown in the chart. Moreover, many planners may be concerned about situations where a site lies on a south by southeast slope or on a gradient of 12 percent, neither of which are shown accurately on the shadow length charts. To increase the accuracy of the charts, the following shadow length equations are presented, so that planners can develop their own very precise data for local circumstances. For communities that are not concerned with such a high degree of accuracy, the approximations shown in the shadow length charts should be sufficient for most development situations in most latitudes and on most slopes.

In order to achieve maximum accuracy, it is necessary that a planner know the exact latitude of the community and the exact solar altitude and azimuths at that latitude. These can be gathered from a *Nautical Almanac* or from the *ASHRAE Handbook of Fundamentals,* published by the American Society of Heating, Refrigeration and Air Conditioning Engineers. Or, the planner can choose the closest latitude shown on the shadow length charts (which are set forth in 5 degree latitude increments) and the solar altitude and azimuth information presented in the first table of this Appendix (which will reduce the accuracy of the equations).

In using the equations, the following abbreviations will be used:

A_l = solar altitude

A_z = solar azimuth

H = height of object casting shadow

S = true shadow length (as shown in cross-section in figure 84, below).

S_p = plan projected shadow length (the shadow length as shown in a plan view of an object and its shadow; it presumes a distance measured on a hypothetical level surface, instead of the varying irregularities of an actual site,

S_a = slope angle

S_l = slope percent/100.

For the simple condition of shadows on a level surface or 0% slope, the shadow length is given immediately by the formula:

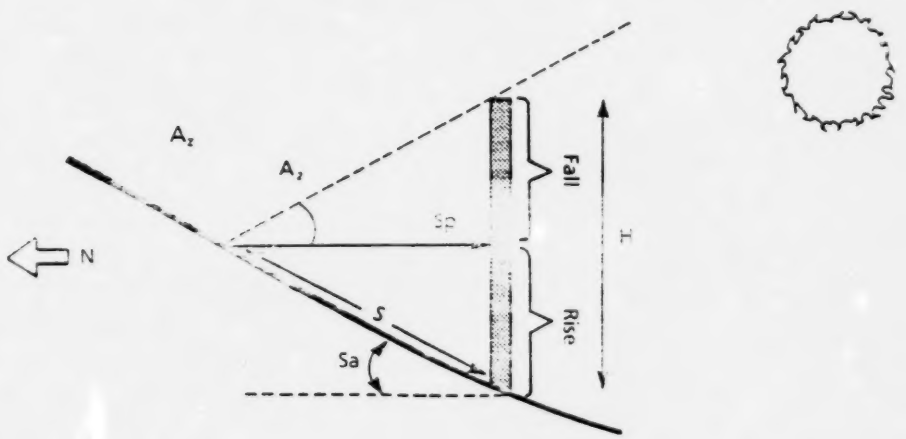
(1) $S = H/\tan A_l$

The shadow will fall in a direction exactly opposite the direction of the sun, numerically:

(2) A_z shadow = A_z sun ± 180°

On a sloping surface, the shadow length calculation becomes more complex due to the rise or fall of the land. If the land rises in the same direction as the sun's rays are going, the shadow will be shortened; if the land falls away, the shadow will be lengthened.

An Illustration of Various Terms Used in Shadow Length Equations



This fact may be mathematically expressed:

(3) $Fall_{shadow} = S_p \times \tan(A_l)$

(4) $Rise_{land} = S_p \times \tan(S_a)$

$= S_p \times S_l$

The rise of the land and fall of the shadow will equal the height of the shading object.

(5) $H = fall = rise$

$= S_p \times \{\tan(A_l) + \tan(S_a)\}$

or

(6) $H = S_p \times \{\tan(A_l) + S_l\}$

Thus, the plan projected shadow length is:

(7) $$S_p = \frac{H}{\{\tan(A_l) + S_l\}}$$

But the slope of the land does not usually lie in the direction of the sun's rays, and the slope along this direction will be different from the true slope of the land. To account for the angle between the sun's rays and the slope of the land, we need to modify equation 7 to:

(8) $$S_p = \frac{H}{\tan(A_l) + S \times \cos(A_z - w)}$$

where w = slope orientation or azimuth

Shadow Projections

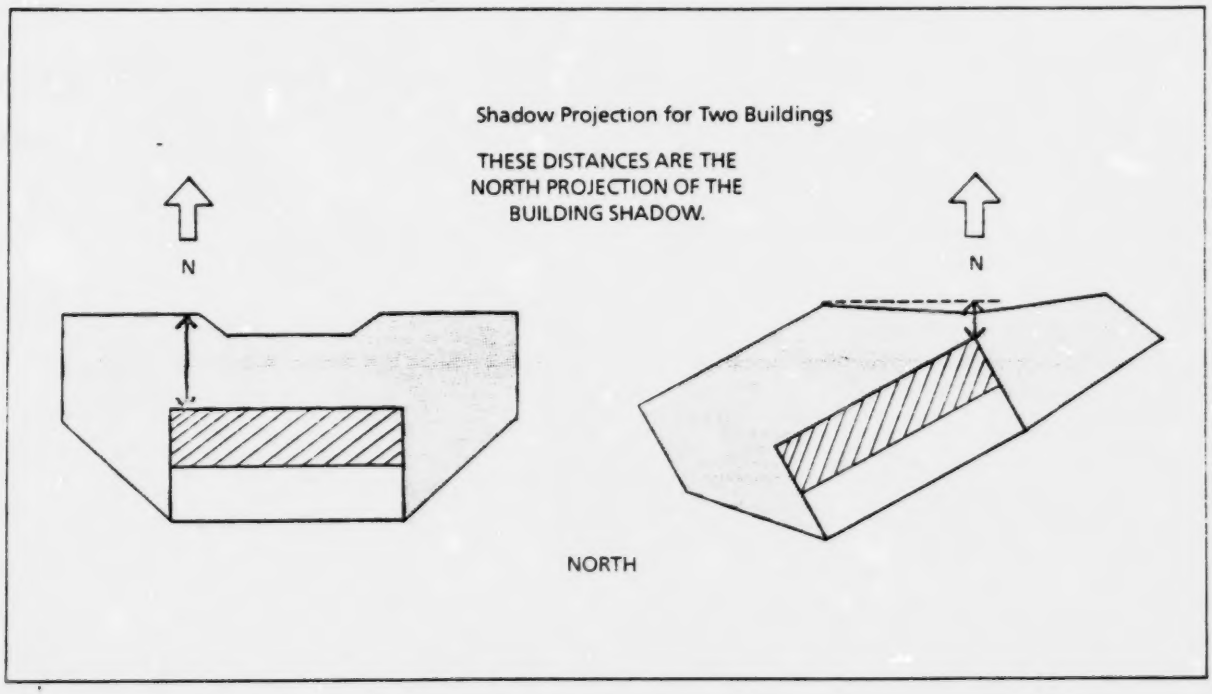
Shadow projections and their importance in planning were discussed in the text. An example of determining the shadow projection of a single pole was also given, but shadow projections can be somewhat more complex than the pole example. Further examples of shadow projections are presented in this portion of the Appendix.

Below are two figures that illustrate the shadow projection distances for two buildings, one oriented due south and the other southeast. The shadow projection distance marked in these examples indicates how far to the north other buildings must be located in order to avoid being shaded by each other, regardless of the building orientation or the direction and degree of slope of the site

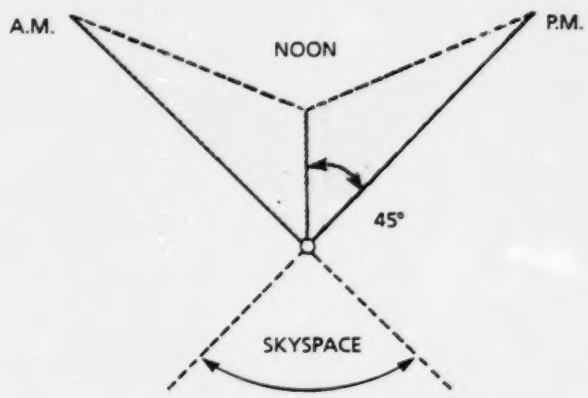
It becomes apparent when examining the illustration that the shadow projection distance is different from shadow length distance, although both are related. In most cases, the shadow projection distance will be less than the length of the longest a.m. or p.m. shadows defined by the 45 degree skyspace used in this guidebook. This is because the north shadow projection is a trigonometric function of both the longest shadow length and the azimuth of the longest shadow. North shadow projection depends on the a.m. or p.m. shadow length, but it also depends on the 45 degree or 50 degree azimuth used to define the extent of shading.

This relationship can best be clarified by a simple example. If one assumes a 10-foot pole and plots the a.m. and p.m. shadow lengths, a shadow similar to the one below occurs.

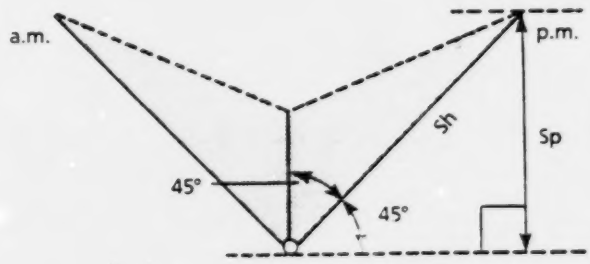
As pointed out in the Planning chapter, the north shadow projection is only the extent to the north to which the longest shadows fall. By drawing a line per-



Shadow Pattern of a Pole



Relation Between Shadow Length and Shadow Projection



Sp = SHADOW PROJECTION
Sh = SHADOW LENGTH

(1) Sp = Sh (sin 45)
(2) Sp = Sh (.707)
(3) Sp = about 70 percent of Sh

North Shadow Projection Table

RATIO OF NORTH PROJECTION OF SHADOW LENGTH TO HEIGHT OF SHADOW-CASTING OBJECT

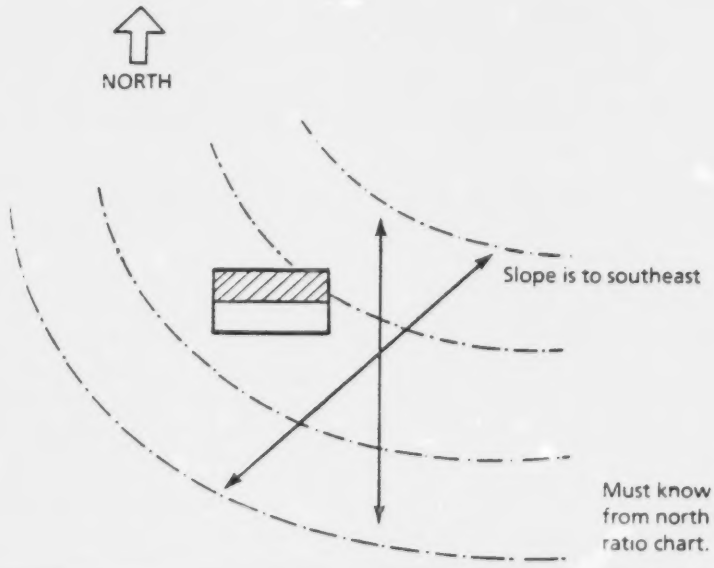
LATITUDE	South Slope 20%	15%	10%	5%	Flat	5%	10%	15%	20%	North Slope
25°	1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	
30°	1.4	1.5	1.6	1.7	1.9	2.1	2.3	2.6	3.0	
35°	1.6	1.8	2.0	2.2	2.5	2.8	3.3	3.9	4.8	
40°	2.0	2.3	2.5	2.9	3.4	4.0	5.1	6.8	10.2	
45°	2.5	2.9	3.4	4.1	5.1	6.8	10.4	21.5	—	
48°	2.9	3.5	4.2	5.3	7.2	11.2	25.4	—	—	
50°	3.3	4.1	5.0	6.5	9.3	16.1	—			

pendicular to this longest northern projection from the pole position, the planner can see that a right triangle is formed. Using simple trigonometry and assuming a flat site, the shadow projection distance becomes the a.m. or p.m. shadow length multiplied by the sine of the azimuth (45 degrees), or, the shadow length multiplied by .707. Thus, the shadow projection is about 70 percent of the longest shadow length in this example.

This relationship means that shadow projection distances depend on shadow lengths. As mentioned in the Basics of Solar Access chapter and in the previous section of this Appendix, shadow length depends on topography—shadows get shorter on south-facing slopes and longer on north slopes. Therefore, the major factor which affects shadow projection is north/south slopes, the same way as the slope affects shadow length. The table below already appeared in the text, but is duplicated here for convenience. This table shows the ratio of an object's height compared to its north shadow projection, taking into account changes in north/south slope, and also changes in latitude. Like the shadow length table shown earlier, it presumes a 45 degree skyspace requirement

To use the table, it is necessary to know only the degree of slope from north to south. For a northeast-facing site, for example, the degree of slope change on a north to south axis must be calculated
When this is known, the ratio found under the appropriate percentage and direction of slope can be multiplied times the height of the object casting the shadow to arrive at the shadow projection.

Generating Slopes for Shadow Projections



APPENDIX A2

PUBLIC SURVEY RESULTS

LETHBRIDGE
ENERGY EFFICIENT STRATEGY
FOR RESIDENTIAL LAND USE

QUESTIONNAIRE

☐

TELEPHONE NO. _____
ADDRESS _____
_____
AREA: W☐ S☐ E☐

1. Tenure/Sex ☐ Renter ☐ Male
☐ Owner ☐ Female

2. Type of House ☐ Single
☐ Two Unit Dwelling
☐ Multi

3. Approximately how much do you spend on: (for household)
_____ Gasoline per week
_____ Public Transit per week
_____ Gas (Natural) per month
_____ Electricity per month

4. How many people in your household travel to work? _____ Please List.

Distance to Work (Round Trip)	Mode of Transport					
	Car as Driver	Car as Passenger	Public Transit	Motor Cycle	Bicycle	Walk
1. _____ Miles	☐	☐	☐	☐	☐	☐
2. _____ Miles	☐	☐	☐	☐	☐	☐
3. _____ Miles	☐	☐	☐	☐	☐	☐
4. _____ Miles	☐	☐	☐	☐	☐	☐

5. Do you think energy saving is important?
For transportation ☐YES ☐NO Why _____
_____
In the home ☐YES ☐NO Why _____
_____

6. Have you taken measures to reduce energy costs?
For transportation ☐YES ☐NO
In the home ☐YES ☐NO

7. If "YES", what measures have you taken?

Transportation	Home
_____	_____
_____	_____
(ie: smaller car, public transit, car pool)	(ie: insulation, air tightness, turn down thermostat)

8. If "NO", are you considering taking any energy conservation measures?
☐YES ☐NO

If so, what?

Transportation	Home
_____	_____
_____	_____
_____	_____

continued on reverse

9. If you are not considering taking conservation measures, why not?

_____

_____

_____

10. Are you considering

Buying a new home? ☐ YES ☐ NO

Renovating your home? ☐ YES ☐ NO

11. Will energy costs be a factor in your selection?

☐ YES ☐ NO

12. How much extra would you be prepared to pay for a new home if you could save 60¢ every year on your heating bills?

☐ NO EXTRA

_____ DOLLARS

13. How much extra would you be prepared to pay on a home renovation if you could save 35¢ every year on your heating bills?

☐ NO EXTRA

_____ DOLLARS

14. Would finding a location close to work be an important factor if you were considering moving to a new house?

☐ YES Why _____

_____

☐ NO Why _____

_____

15. Do you think energy efficient housing looks unusual?

☐ YES

☐ NO

16. Would you like to see more housing closer to the City Centre?

☐ YES Why _____

_____

☐ NO Why _____

_____

17. Would you like to see smaller lots if it could reduce cost and lower taxes?

☐ YES Why _____

_____

☐ NO Why _____

_____

1.0 SUMMARY OF QUESTIONNAIRE RESULTS

The resident survey related to energy conservation (Task 7 of the proposed work program) was conducted by telephone interview during the period September 25 to 28, 1982. The aim of the survey was to obtain opinions, attitudes, and base data regarding potential energy conservation in housing and transportation. A sample of the questionnaire is shown in Exhibit 1.

The survey team obtained an excellent response to the questionnaire and a total of 222 interviews were completed within the four days. By the end of the survey period a number of people interviewed were already aware of the survey and were most interested in participating. We believe this public awareness of the "Lethbridge Energy Study" will be an excellent beginning to the education element which is essential if a strategy for energy conservation is to be successful.

1.1 QUESTION 1 and 2

Question 1 and 2 were base data questions related to housing tenure, sex of the respondent and type of dwelling. Of the total 222 people interviewed, the following breakdown resulted:

152	Owners	135	Females
70	Renters	87	Males
169	Detached Dwellings	115	South Lethbridge
17	Two Unit Dwellings	78	North Lethbridge
36	Attached "Multi" Dwellings	29	West Lethbridge

The above figures are considered to form a good representative sample. The higher number of female respondents reflects the norm or trend in telephone interviews of this type when interviews are conducted during the day as well as in the evening.

1.2 QUESTION 3

Question 3 attempted to obtain information on household expenditures for gasoline, public transit, natural gas and electricity. The results with respect to natural gas and electricity have been cross checked against the actual average usage using City consumption figures. The following table shows the annual average for each category.

Annual Average Expenditure	
$1180	Gasoline
$46	Public Transit
$555	Natural Gas
$311	Electricity
TOT[illegible]OR MAJOR FUELS	$2,092

The actual average home expenditures for electricity, based on the utility company's records, was $318.24, very close to the survey figures of $311. However, the $555 average annual natural gas cost derived from the survey was considerably below the utility company's average billings of $718.35. It should be noted, that the basic annual energy charge without the additional fixed charges or revenue taxes, would produce an average of $548.32, a figure much closer to the survey result.

The survey shows clearly that gasoline costs for the average household exceeds the combined totals for expenditures on public transport, natural gas and electricity. It follows from this analysis, that any strategy aimed at energy conservation must consider both residential and transportation factors.

1.3 QUESTION 4

Question 4 was devised to obtain information on journey to work distances and mode of transport. The average journey to work, round trip distance of survey respondents was 11.3 km (7 miles) and on average each household generated 1.4 person trips between home and work.

The following table shows the breakdown by transportation mode.

TRANSPORTATION MODE

	# TRIPS	(%)	
	263	(84)	Car (As Driver)
	18	(5.8)	Car (As Passenger)
	13	(4.2)	Public Transit
	1	(0.3)	Motor Cycle
	0	(0.0)	Bicycle
	15	(4.7)	Walk
TOTAL	310		

As expected, the private car with driver only is the dominent travel to work mode. Again, the objective from an energy conservation strategy would be to increase public transit usage and design areas, where possible, to encourage walking or bicycle trips. Encouraging car

pools has been successful in some cities but it is not likely to be popular in Lethbridge with short travel distances and fairly minimal parking problems.

1.4 QUESTION 5

Over 95% of respondents thought that energy saving is important for transportation and in the home. This percentage did not change between owners and renters. This is a good response and again indicates a positive attitude among City residents towards energy conservation.

1.5 QUESTION 6 and 7

When asked if they had "taken measures to reduce energy costs", approximately 65% of all respondents indicated that they had taken energy conservation measures with respect to transportation and 81% with respect to home energy conservation. As expected, a higher percentage of home owners (85%) had taken house related conservation measures compared to 73% for renters.

The most frequent energy conservation measures stated are shown below.

TRANSPORTATION CONSERVATION MEASURES

# REPLIES	(%)	CONSERVATION MEASURE STATED
52	(36)	Smaller Car
45	(31)	Reduced Trip Lengths and Frequency
24	(17)	Bicycle/Walk
10	(7)	Use Public Transit More Often
5	(3.5)	Keep Car Tuned Up
5	(3.5)	Drive More Slowly
2	(2)	Use Diesel Fuel

HOME CONSERVATION MEASURES

# REPLIES	(%)	CONSERVATION MEASURE
83	(30)	Turn Down Thermostat
69	(24)	Install Extra Insulation
69	(24)	Turn Lights Off
26	(9)	Improve Air Tightness - Sealing, Stripping
10	(3.5)	Install Fireplace or Stove
9	(3)	Re-Build Furnace
9	(3)	Use Appliances Less
4	(1.5)	Use Microwave For Cooking
3	(1)	Install Heavy Blinds On Windows
3	(1)	Turn Down Water Heater

The notable difference between renters and owners with regard to home conservation measures was in home insulation. Only 2 renters had insulated as against 69 in the ownership category. While this result is understandable, it does emphasize some obvious problems in trying to improve conservation measures in rental housing. High standards at the building construction stage is particularly important for rental units. With respect to transportation, more renters were walking or bicycling to work while more home owners were using public transit. This trend may be a result of the higher portion of rental housing closer to the City centre.

1.6 QUESTION 8

The respondents who had not taken any energy saving measures were asked if they were "considering taking any energy conservation measures". Only 17 of the 89 asked indicated they would. The purchase of a smaller car or the installation of a wood stove or fireplace were the most frequently stated energy conservation measures.

1.7 QUESTION 9

Most of the people interviewed who were not considering taking energy conservation measures, were either renting their houses or considered they could not do any more to save energy. Some indicated that their houses were already well insulated or that they had bought new houses and therefore additional measures were not required.

With respect to transportation, the most common response was that "a car was needed for work" and therefore public transportation would not be a practical alternative.

1.8 QUESTION 10

Question 10 asked the persons interviewed if they were considering buying a new home or renovating their existing home. The results are summarized in the following table.

HOME PURCHASE/RENOVATION TRENDS

	OWNERS	RENTERS	TOTAL
New Home Purchase	7 (4.6%)	21 (30%)	28 (12.6%)
Renovation	35 (23%)	1 (1.4%)	36 (16%)

The results of this question are not unexpected. People who are renting are more interested in purchasing a home while those who already own show a higher interest in renovation. If this sample is projected City wide, it can be seen that considerable activity could occur both in renovations and new home purchases in the long term, provided the housing market and economy in general returns from the present recession.

1.9 QUESTION 11

This question asked if "energy costs would be a factor" in their selection of a new home or type of renovation. Over 73% of respondents indicated that it would be a factor. Again, this is an indication that people are aware of energy related costs to some degree and that City residents may be assessing future house purchases or renovation work with energy conservation in mind. However, it is not possible to tell the priority individuals would give to this factor.

1.10 QUESTIONS 12 and 13

Questions 12 and 13 were perhaps the most difficult of the survey. The respondents were asked how much extra they would be prepared to pay for a new home or home renovation, if they could save 60% and 35% respectively each year on heating bills. The percentage figure for new homes was based on the average energy savings possible on a new home by spending $5,000 to $6,000 dollars on energy conservation measures. The average energy savings on home renovations is more difficult to estimate since there is a wide range of renovation projects some of which could incorporate energy saving features. The 35% figure was considered to be a realistic average. The objective of the questions was to see if people had thought about the magnitude of saving possible and secondly to find out if the respondents cost estimates were close to the actual costs.

Overall, the response was not high. Eight respondents gave figures for new homes and five gave estimates for renovations. The average additional expenditure for energy conservation in a new home was calculated to be $6,800 and $1,900 for renovations. These figures are very close to the real cost estimates.

1.11 QUESTION 14

The respondents interviewers who were considering purchasing a new house were asked if "finding a location close to work would be an important factor". The results were fairly evenly split with 44% answering "yes" and 48% answering "no". The remaining 8% were in the "don't know" category.

The most frequent reasons given both for and against a location close to work are given below.

HOUSE/WORK LOCATION

"YES" RESPONSE		"NO" RESPONSE	
# of Replies (%)	Reason	# of Replies (%)	Reason
19 (41)	Saves money	18 (56)	Retired
9 (20)	Saves time	11 (34)	City not that big
10 (22)	Convenient	3 (10)	Schools more important
8 (17)	Can walk to work		

It is interesting to note that in the "no" category, excluding retired people, the most frequent responce was that the city was not "that big". This attitude may be quite commonplace in Lethbridge particularly among those who have moved from a larger City.

1.12 QUESTION 15

This short question was introduced to assess peoples perception of an energy efficient house. The idea of large windows, angled roofs and solar collector has been introduced over the years through many of the "home" magazines showing pictures of exotic "solar houses". However, recent examples of energy conserving homes show that almost any home design can be built to be energy efficient. Of the 219 respondents who answered the question "do you think energy efficient housing looks unusual", 25% answered "yes", 54% answered "no" and 21% did not know.

1.13 QUESTION 16

The majority of people who were asked if they "would like to see more housing closer to the City Centre" answered "no". Of the 222 replies 32% answered "yes", 48% answered "no" 14% were not sure and 6% answered both "yes" and "no". The most frequent reasons given are shown below.

DOWNTOWN HOUSING DEVELOPMENT

"YES" RESPONSE		"NO" RESPONSE	
# of Replies (%)	Reason	# of Replies (%)	Reason
26 (38)	Convenient	20 (25)	Congestion
12 (18)	Saves Money	13 (16)	No Need
8 (12)	More apartments	11 (14)	Too crowded already
8 (12)	Good for 'seniors'	8 (10)	Downtown meant for business
7 (10)	Can walk to work	7 (9)	Like more space
4 (6)	Have no car	6 (7.5)	Downtown not good for families
3 (4)	Downtown needs	5 (6)	Like quietness
		4 (5)	City is too small
		4 (5)	Res/shopping/business do not mix
		2 (2.5)	Downtown is dwindling

The results of this question are a clear indication that distance to downtown and convenience for shopping and work are not priorities with many people.

1.14 QUESTION 17

The final question asked the respondent if he or she "would like to see smaller lots if it would cut costs and lower taxes?" As with Question 16, most of the people interviewed did not want reduced lot sizes. Of the 222 answers 30% answered "yes", 56% answered "no", 7% did not know and 7% answered both "yes" and "no". The most frequent reasons given are shown below.

SMALLER LOTS

"YES" RESPONSE		"NO" RESPONSE	
# of Replies (%)	Reason	# of Replies (%)	Reason
32 (61)	Costs reduced	41 (35)	Enjoy space ("need it")
10 (19)	Less maintenance	21 (18)	Small enough already
3 (6)	If designed well	17 (15)	Privacy
3 (6)	Gives young people a chance to own	14 (12)	Liked garden space
2 (4)	Better for seniors	12 (10)	Space for children to play
2 (4)	More efficient use of space	7 (6)	Space for garage
		5 (4)	Better appearance

The dominant response in the "no" category was related to the need for space and the fact that many enjoyed a larger lot. The strong rural background of people living in Lethbridge may reinforce this feeling and produce a slightly higher demand for larger lots. Overall the ratio was approximately 2:1 for larger lots.

LETHBRIDGE ENERGY EFFICIENT STRATEGY STUDY RESULTS

1. Tenure/Sex — 222 Renters & Owners — 87 Males, 135 Females

2. Type of House

Single	Two Units	Multi
169	17	36

3. Spend on:

Gasoline	Transit	Natural Gas	Electricity
$2.50 - $200.00	$0 - $20.00	$10 - $150.00	$7. - $95.00

See grid for exact amounts.

4. See grid for breakdown.

5. Do you think energy saving is important?

	Yes	No	Don't Know	See Questionnaire for reasons
For transportation:	210	4	6	
In the home:	215	3	4	

6. Have you taken measures to reduce energy costs?

	Yes	No	Don't Know	See Questionnaire for reasons
For transportation:	144	26		
In the home:	181	41		

7. See Questionnaire

8. If "NO", are you considering taking any energy conservation measures?

Yes	No	Not Asked
17	72	97

See Questionnaire for reasons.

9. See Questionnaire for reasons.

10. Are you considering

	Yes	No
Buying a new home:	28	194
Renovating your home:	Yes	No
	36	186

11. Will energy costs be a factor in your selection?

Yes	No
47	14

12. How much extra would you be prepared to pay for a new home if you could save 60% every year on your heating bills?

No Extra	Don't Know	Gave Amounts
2	19	9

See grid for figures.

13. How much extra would you be prepared to pay on a home renovation if you could save 35% every year on your heating bills?

No Extra	Don't Know	Gave Amounts
22	8	6

See grid for figures.

14. Would finding a location close to work [illegible] important factor if you were considering moving to a new house?

Yes	No	Don't Know	Not asked question as question was not relevant
61	66	10	64

See Questionnaire for reasons.

15. Do you think energy efficient housing looks unusual?

Yes	No	Don't Know	Answered Yes and No
54	118	47	5

See Questionnaire for reasons.

16. Would you like to see more housing closer to the City Centre?

Yes	No	Don't Know	Answered Yes and No
73	106	31	12

See Questionnaire for reasons.

17. Would you like to see smaller lots if it could reduce cost and lower taxes?

Yes	No	Don't Know	Answered Yes and No
67	124	16	15

Area:	South	115	51.80%
	North	78	35.14%
	West	29	13.06%
		222	

LETHBRIDGE ENERGY EFFICIENT STRATEGY STUDY RESULTS

1. Tenure/Sex — 152 Owners — 60 Males, 92 Females

2. Type of House

Single	Two Units	Multi
147	4	1

3. Spend on:

Gasoline	Transit	Natural Gas	Electricity
$2.50 - $130	$0.50 - $12	$10 - $114	$7 - $95

See grid for exact amounts.

4. See grid for breakdown.

5. Do you think energy saving is important?

For transportation:	147	Yes	2	No	3	Don't Know — See Questionnaire for reasons
In the home:	148	Yes	2	No	2	Don't Know — See Questionnaire for reasons

6. Have you taken measures to reduce energy costs?

For transportation:	99	Yes	52	No	1	Don't Know — See Questionnaire for reasons
In the home:	130	Yes	22	No		Don't Know — See Questionnaire for reasons

7. See Questionnaire

8. If "NO", are you considering taking any energy conservation measures?

12	Yes	43	No	97	Not Asked

See Questionnaire for reasons.

9. See Questionnaire for reasons.

10. Are you considering

Buying a new home: 7 Yes 145 No

Renovating your home: 35 Yes 117 No

11. Will energy costs be a factor in your selection?

31 Yes 11 No

12. How much extra would you be prepared to pay for a new home if you could save 60% every year on your heating bills?

1 No Extra 2 Don't Know 4 Gave Amounts

See grid for figures.

13. How much extra would you be prepared to pay on a home renovation if you could save 35% every year on your heating bills?

8 No Extra 21 Don't Know 6 Gave Amounts

See grid for figures.

14. Would finding a location close to work be an important factor if you were considering moving to a new house?

27 Yes 47 No 3 Don't Know 75 Not asked question as question was not relevant

See Questionnaire for reasons.

15. Do you think energy efficient housing looks unusual?

40 Yes 81 No 26 Don't Know 5 Answered Yes and No

See Questionnaire for reasons.

16. Would you like to see more housing closer to the City Centre?

43 Yes 76 No 24 Don't Know 9 Answered Yes and No

See Questionnaire for reasons.

17. Would you like to see smaller lots if it could reduce cost and lower taxes?

45 Yes 87 No 8 Don't Know 12 Answered Yes and No

Area:	West	16	10.53%
	North	60	39.47%
	South	76	50.00%

LETHBRIDGE ENERGY EFFICIENT STRATEGY STUDY RESULTS

1. Tenure/Sex — 70 Renters — Owners — 27 Males, 43 Females

2. Type of House

Single	Two Units	Multi
22	13	35

3. Spend on:

Gasoline	Transit	Natural Gas	Electricity
$3 - $200	$0 - $20	$12 - $150	$7 - $50

See grid for exact amounts.

4. See grid for breakdown.

5. Do you think energy saving is important?

	Yes	No	Don't Know	See Questionnaire for reasons
For transportation:	65	2	3	
In the home:	67	1	2	

6. Have you taken measures to reduce energy costs?

	Yes	No	Don't Know	See Questionnaire for reasons
For transportation:	45	25		
In the home:	51	19		

7. See Questionnaire

8. If "NO", are you considering taking any energy conservation measures?

Yes	No	Not Asked
9	29	

See Questionnaire for reasons.

9. See Questionnaire for reasons.

10. Are you considering

	Yes	No
Buying a new home:	21	49
Renovating your home:	1	69

11. Will energy costs be a factor in your selection?

Yes	No
16	3

12. How much extra would you be prepared to pay for a new home if you could save 60% every year on your heating bills?

No Extra	Don't Know	Gave Amounts
1	17	3

See grid for figures.

13. How much extra would you be prepared to pay on a home renovation if you could save 35% every year on your heating bills?

No Extra	Don't Know	Gave Amounts
	1	

See grid for figures.

14. Would finding a location close to work be an important factor if you were considering moving to a new house?

Yes	No	Don't Know	Not asked question as question was not relevant
34	19	7	9

See Questionnaire for reasons.

15. Do you think energy efficient housing looks unusual?

Yes	No	Don't Know	Answered Yes and No
14	37	21	

See Questionnaire for reasons.

16. Would you like to see more housing closer to the City Centre?

Yes	No	Don't Know	Answered Yes and No
30	30	7	3

See Questionnaire for reasons.

17. Would you like to see smaller lots if it could reduce cost and lower taxes?

Yes	No	Don't Know	Answered Yes and No
22	37	8	3

Area:	South	39	55.71%
	North	18	25.72%
	West	13	18.57%

APPENDIX A3

IMPLICATIONS OF ENERGY RETROFIT ON MUNICIPAL BYLAWS

SOURCE: Impact. The Canadian Association of Housing Renewal Officials. Volume 5, Number 4

The implications of energy retrofit on municipal bylaws

This study was prepared for the Technical Research Division, Policy Development and Research Sector of CMHC by Middleton Associates. Its purpose was to examine whether or not new energy conservation measures which upgrade thermal efficiency are creating conflicts between building planners, developers and homeowners and the provisions of municipal by-laws. Where conflicts arose, this study examines how those conflicts were resolved. Finally, the study is concerned with the potential for further conflicts and approaches to reducing these potential conflicts.

The scope of the study is limited in the following ways:

—it is restricted to a consideration of energy use by existing buildings.

—the conclusions drawn are primarily provided by a mail survey of municipal officials (41), provincial officials (3), and others including renovators and public interest groups (5).

—the time budget constraints on the project required use of an untested questionnaire and only allowed the participation of the larger communities.

Information on bylaws, codes and regulations affecting retrofitting activity was gathered through the mail survey.

The questionnaire was prepared after preliminary discussions with officials from the cities of Toronto and Ottawa. The overall response rate to the questionnaire was 33 per cent and the municipal areas from which responses were received contain 25 per cent of the total Canadian population.

The following are excerpts from the report:

BUILDINGS AND ENERGY USE

Buildings are the most durable energy using equipment. Although automobiles and appliances may operate for ten to twenty years, the life expectancy of a house is 60 years. In addition to being durable, buildings are relatively *energy-intensive*. It is estimated that 40 per cent of all energy use in Canada is building use.

Rising energy prices mean that although it may be too expensive to replace these buildings, it may be too expensive to operate them as they are; therefore it is likely to be considerable effort to upgrade their thermal performance.

Upgrading the thermal performance of buildings can take several forms. The simplest, most common and cheapest measures are housekeeping measures such as: weather-stripping, night-setbacks of thermostats, closing drapes on winter nights and improving furnace maintenance. The next level of upgrading is what has been termed *first generation retrofits*: attic insulation, storm windows and doors, hotwater tank blankets and other measures which cause little or no change in the building structure. Finally, there is *second generation retrofits*: e.g. additions of greenhouses or solaris, exterior insulation, solar panels, wood stoves, heat pumps, or *trombe walls*.

The possibility of conflicting with municipal bylaws increases as upgrading moves from housekeeping to second generation retrofits because possible changes to the building become more extensive.

Tables 1 and 2 illustrate the extent of first and second generation retrofitting activities in various communities.

TABLE 1 EXTENT OF HOMES HAVING COMPLETED FIRST GENERATION RETROFITTING ACTIVITIES

	0—1%		1—10%		10—25%		25—50%		> 50%		Total	
	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3
Atlantic Provinces					2	148			3	157	5	305
Quebec					3	196			3	177	6	373
Ontario			1	10	4	779	3	764	9	1.745	17	3.297
Prarie Provinces					2	678	1	160			3	836
British Columbia			4	269	3.5**	341	2.5**	364	2	154	12	1.128
CANADA			5	279	14.5**	2.140	6.5**	1.288	16	2.233	43	5.939

*Population represented by respondents **Two responses were received from one city

TABLE 2 EXTENT OF HOMES HAVING COMPLETED SECOND GENERATION RETROFITTING ACTIVITIES

	0—1%		1—10%		10—25%		25—50%		> 50%		Total	
	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3	# of Responses	Pop* 10^3
Atlantic Provinces	1	88			3	207			1	10	5	305
Quebec			6	373							6	373
Ontario			10	2.235	5	892	2	170			17	3.297
Prarie Provinces			3	836							3	836
British Columbia	1	78	8	901	2	68	1	82			12	1.128
CANADA	2	166	27	4.345	10	1.167	3	252	1	10	43	5.939

CONFLICTS TO DATE AND POTENTIAL CONFLICTS

In spite of the relatively low number of second generation retrofits, a significant number of conflicts between proposed energy conservation measures and municipal bylaws, have already occurred. There is potential for still more conflicts.

Three areas, bylaws of municipal jurisdiction, provide the greatest potential for conflicts i.e. zoning bylaws, building codes and property assessment laws.

The following table gives an illustration of the areas of potential conflict. (Table 3)

CONFLICT RESOLUTION

Although many respondents felt that municipal bylaws create a potential for conflicts, even more indicated that their municipalities were interested in promoting and supporting energy conservation, expecially by removing barriers contained by municipal bylaws and regulations.

There are four basic mechanisms for resolving conflicts;

—abandon or modify the plan
—appeal to the committee of adjustment or its equivalent
—modiby the bylaw
—change assessment criteria for energy efficiency upgrading activities

In its conclusions the study states that as energy prices rise and energy savings associated with housekeeping and first generation retrofitting are saturated, the number of actual conflicts are likely to increase. As the conflict becomes a barrier or disincentive pressure will be placed on City Council to modify bylaws.

In its recommendations the report suggests that further surveys need to be conducted, especially a more extensive survey of builders and renovators. In addition an assessment of how much difference, in energy Units, conforming with the bylaws will make.

In addition, municipalities may be assisted in removing barriers to energy retrofitting caused by bylaws. The first prerequisite to

TABLE 3 AREAS OF POTENTIAL CONFLICT

ENERGY UPGRADING MEASURE	AREA OF POTENTIAL CONFLICT	COMMENTS
Exterior Insulation	Zoning Bylaws	Exterior Insulation may encroach into restricted areas of sideyards of extend over required set-backs.
	Fire Code	Exterior Insulation may lower the time before combustion of materials inside the insulation by keeping heat in.
	Assessment Value	Where assessments are based o floor area of the building measured on the perimeter, the assessment value may be increased unreasonably.
	Heritage Preservation Laws	The change in appearance with exterior insulation may conflict with heritage laws.
Solaria, Greenhouses, Enclosed Porches	Building Codes	Such additions may encroach upon the minimum spatial separation. The code may require overhead glazing to withstand high stresses.
	Zoning Bylaws	Maximum permissible gross floor areas, lot coverages or building length may be exceeded. Set backs may be encroached upon.
	Assessment Value	Increased energy efficiency may not be sufficient to compensate for increased assessment value.
	Heritage Preservation Laws	Additions may alter the Heritage value.
Heat Pumps	Zoning Bylaws	Heat pumps may enter in restricted zones in side yards or exceed setbacks.
	Noise Bylaws	Heat pump noise may exceed allowable levels.
	Municipal Water Supply	Some Municipalities may be unable or unwilling to supply water to and accept discharges from water source heat pumps.
Windows	Building Code	Reorienting windows to increase solar gain may create conflicts with regments for minimum distance from glazing to neighbouring properties.
	Zoning Bylaws	Skylights may exceed the maximum allowable height.
	Heritage Preservation Laws	All external changes to street facade of houses may be prohibited.
Solar Panels	Property Maintenance Bylaws	Solar panels may be considered as unsightly objects and detrimental to the appearance of the building and hence be prohibited.
	Assessment Value	An increase in assessed value caused by a solar collector may make the collector uneconomical.

	Zoning Bylaws	Solar panels may protrude above maximum allowable heights or into required setback zones. Glare may be a problem.
	Heritage Preservation	In designated areas, all external changes to the street facade—including the addition of solar panels—may be prohibited.
New Building Systems (eg. no foundation, prefab wall sections, etc.)	Building Code	Some new building systems, though energy efficient, may not conform with the existing building code.
Woodstoves	Building Code	The code may restrict how stoves are installed.
	Air Quality Bylaws	Woodstoves or furnaces may violate pollution control Bylaws.
Wood Storage	Property Maintenance Bylaw	Storage of wood may be considered unsightly.
Clotheslines	Property Maintenance Bylaw	Solar Clothes dryers may be considered unsightly and be prohibited.
Condensing Gas Furnaces	Municipal Water	Acidity of condensate may exceed maximum allowable from residential buildings.
Coal Burning	Pollution Control Bylaw	Emission from coal-burning may exceed maximum allowable levels.
Heat Recovery	Building Code	Some uses for waste heat are prohibited.
Loose Fill Insulation	Building Code	Potential fire hazard.
Multi-layer Vapour Barrier	Building Code	These are not allowed by the National Building Code.

removing these obstacles to retrofitting could be provided by Model bylaws appropriate to each province which could be designed where there is no precedent to be followed.

Retrofitting may create the need for new laws to protect the health and safety of citizens. For example, the building code may need modification to ensure that woodstoves and solar collectors are properly installed and that adequate ventilation is provided in air tight buildings.

Information about what has been and can be done needs to be made available to those who can use the information. A mechanism such as an information clearing house is needed to allow municipalities to find out what has been done in other municipalities.

Building inspectors and property standards officers may need training to allow them to advise homeowners on how to resolve conflicts between bylaws and retrofitting activities. Too often to building inspectors, they are seen as a source of conflict and bureaucratic headaches.

The study stresses the fact that action is needed now. Even though municipal bylaws are not currently a major barrier to energy retrofitting activities, primarily this is because these activities are still in the early stages. As upgrading advances, the actual number of conflicts are likely to increase dramatically unless corrective action is taken now. By recognizing the potential for conflicts now and beginning to remove those obstacles, the problem can be reduced greatly and the time required for Canada to achieve an *efficient building stock* will be shortened.

Anyone interested in obtaining a copy of the report can contact the Information Officer CMHC National Office, 160 Montreal Rd., Ottawa, Ontario.

APPENDIX B1

HOTCAN 2.0 COMPUTER RUNS

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*     DIVISION OF BUILDING RESEARCH       *
*     SASKATOON, SASKATCHEWAN, 1982       *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 1

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	6.75
MAIN WALLS	84.94	2.11		
TOTAL	84.94	2.11	40.19	16.25
DOORS	3.9	.53		
TOTAL	3.9	.53	7.39	2.99
BASEMENT AB.GD.	24.35	1.41		
TOTAL	24.35	1.41	17.28	6.99
BASEMENT 600MM.	24.35	1.41		
TOTAL	24.35	1.41	8.06	3.12
BASE. TO FLOOR	48.7	0		
TOTAL	48.7	0	37.55	14.56
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	10.92	4.23
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.39	2.86
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
AIR CHANGE	.5/HR	487.57 M3	75.2	30.4

APPENDIX B1

HOTCAN 2.0 COMPUTER RUNS

```
* * * * * * * * * * * * * * * * * * * *
*                                       *
*            PROGRAM HOTCAN!            *
* NATIONAL RESEARCH COUNCIL OF CANADA   *
*    DIVISION OF BUILDING RESEARCH      *
*    SASKATOON, SASKATCHEWAN, 1982      *
*                                       *
* * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 1

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	6.75
MAIN WALLS	84.94	2.11		
TOTAL	84.94	2.11	40.19	16.25
DOORS	3.9	.53		
TOTAL	3.9	.53	7.39	2.99
BASEMENT AB.GD.	24.35	1.41		
TOTAL	24.35	1.41	17.28	6.99
BASEMENT 600MM.	24.35	1.41		
TOTAL	24.35	1.41	8.06	3.12
BASE. TO FLOOR	48.7	0		
TOTAL	48.7	0	37.55	14.56
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	10.92	4.23
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.39	2.86
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
AIR CHANGE	.5/HR	487.57 M3	75.2	30.4

```
* * * * * * * * * * * * * * * * * * * * *
*                                       *
*            PROGRAM HOTCAN!            *
* NATIONAL RESEARCH COUNCIL OF CANADA   *
*    DIVISION OF BUILDING RESEARCH      *
*    SASKATOON, SASKATCHEWAN, 1982      *
*                                       *
* * * * * * * * * * * * * * * * * * * * *
```

RUN 2

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	6.75
MAIN WALLS	84.94	2.11		
TOTAL	84.94	2.11	40.19	16.25
DOORS	3.9	.53		
TOTAL	3.9	.53	7.39	2.99
BASEMENT AB.GD.	24.35	1.41		
TOTAL	24.35	1.41	17.28	6.99
BASEMENT 600MM.	24.35	1.41		
TOTAL	24.35	1.41	8.06	3.12
BASE. TO FLOOR	48.7	0		
TOTAL	48.7	0	37.55	14.56
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	10.90	4.27
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.39	2.96
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	2.96
AIR CHANGE	.5/HR	487.57 M3	75.2	30.4

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 10.35 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 17.8
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	145.74	.09	133.06	170.06
FEB	130.33	.13	112.95	149.95
MAR	114.33	.19	92.86	129.86
APR	75.42	.25	56.64	93.64
MAY	0	1	0	37
JUN	0	1	0	37
JUL	0	1	0	37
AUG	0	1	0	37
SEP	0	1	0	37
OCT	53.19	.29	38	75
NOV	76.38	.13	83.47	120.47
DEC	123.9	.09	112.83	149.83

HEATING SEASON STARTS IN OCT AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 68.56 J. OR 19045.48 KWHRS
ANNUAL SOLAR FRACTION = .15

PROGRAM HOTCAN'
NATIONAL RESEARCH COUNCIL OF CANADA
DIVISION OF BUILDING RESEARCH
SASKATOON, SASKATCHEWAN, 1982

RUN 3

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONA HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	8.14
MAIN WALLS	84.94	2.11		
TOTAL	84.94	2.11	40.19	19.58
DOORS	3.9	.53		
TOTAL	3.9	.53	7.39	3.6
BASEMENT AB.GD.	24.35	1.41		
TOTAL	24.35	1.41	17.28	8.42
BASEMENT 600MM.	24.35	1.41		
TOTAL	24.35	1.41	8.06	3.76
BASE. TO FLOOR	48.7	0		
TOTAL	48.7	0	37.55	17.54
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	10.92	5.1
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.39	3.45
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.57
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.57
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.57
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.57
AIR CHANGE	.22/HR	487.57 M3	33.09	16.12

```
* * * * * * * * * * * * * * * * * * * * *
*                                       *
*            PROGRAM HOTCAN!            *
* NATIONAL RESEARCH COUNCIL OF CANADA   *
*    DIVISION OF BUILDING RESEARCH      *
*    SASKATOON, SASKATCHEWAN, 1982      *
*                                       *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 4

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONA HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	9.05
MAIN WALLS	84.94	3.52		
TOTAL	84.94	3.52	24.12	13.82
DOORS	3.9	.53		
TOTAL	3.9	.53	7.39	4.01
BASEMENT AB.GD.	24.35	2.11		
TOTAL	24.35	2.11	11.52	6.51
BASEMENT 600MM.	24.35	2.11		
TOTAL	24.35	2.11	7.1	3.69
BASE. TO FLOOR	48.7	2.11		
TOTAL	48.7	2.11	11.12	5.78
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	15.33	7.97
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.98	4.15
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.97
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.97
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.97
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	3.97
AIR CHANGE	.5/HR	487.57 M3	75.2	38.83

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 8.37 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	111.77	.11	99.1	139.34
FEB	100.2	.17	82.82	123.06
MAR	87.44	.23	67.3	107.54
APR	56.31	.32	38.42	78.66
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	36.4	.39	22.37	62.61
NOV	71.21	.18	58.3	99.54
DEC	93.88	.12	82.81	123.05

HEATING SEASON STARTS IN OCT AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 49.1 GJ, OR 13639.34 KWHRS
ANNUAL SOLAR FRACTION = .19

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 8.68 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 17.8
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	114.44	.11	101.77	138.77
FEB	100.48	.17	83.1	120.1
MAR	87.37	.23	67.24	104.24
APR	55.15	.32	37.33	74.33
MAY	0	1	0	37
JUN	0	1	0	37
JUL	0	1	0	37
AUG	0	1	0	37
SEP	0	1	0	37
OCT	0	1	0	37
NOV	74.98	.17	62.07	99.07
DEC	96.8	.11	85.73	122.73

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 47.54 GJ, OR 13205.58 KWHRS
ANNUAL SOLAR FRACTION = .17

```
* * * * * * * * * * * * * * * * * * * * *
*                                       *
*            PROGRAM HOTCAN!            *
* NATIONAL RESEARCH COUNCIL OF CANADA   *
*    DIVISION OF BUILDING RESEARCH      *
*    SASKATOON, SASKATCHEWAN, 1982      *
*                                       *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 5

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONA HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	11.45
MAIN WALLS	84.94	3.52		
TOTAL	84.94	3.52	24.12	17.47
DOORS	3.9	.53		
TOTAL	3.9	.53	7.39	5.06
BASEMENT AB.GD.	24.35	2.11		
TOTAL	24.35	2.11	11.52	8.2
BASEMENT 600MM.	24.35	2.11		
TOTAL	24.35	2.11	7.1	4.87
BASE. TO FLOOR	48.7	2.11		
TOTAL	48.7	2.11	11.12	7.31
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	15.33	10.07
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.98	5.24
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.02
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.02
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.02
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.02
AIR CHANGE	.22/HR	487.57 M3	33.09	22.68

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 6.7 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	80.47	.16	67.8	108.04
FEB	70.36	.23	54.06	94.3
MAR	60.48	.31	41.47	81.71
APR	36.04	.45	20	60.24
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	49.81	.25	37.13	77.37
DEC	66.78	.17	55.71	95.95

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 30.03 GJ. OR 8342.01 KWHRS
ANNUAL SOLAR FRACTION = .24

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*      DIVISION OF BUILDING RESEARCH      *
*      SASKATOON, SASKATCHEWAN, 1982      *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 6

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	7.04		
TOTAL	100	7.04	14.2	9.21
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	12.25
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.7
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	4.98
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.91	3.01
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	8.5	5.21
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	16.05	9.84
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.98	4.89
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	4.68
NORTH WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	3.31
EAST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	3.31
WEST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	3.31
AIR CHANGE	.5/HR	487.57 M3	75.2	45.77

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 7.33 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 17.8
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .72
EAST = .72 WEST = .72
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	92.38	.13	80.51	117.51
FEB	80.87	.2	64.75	101.75
MAR	70.15	.26	52.01	89.01
APR	43.36	.36	27.72	64.72
MAY	0	1	0	37
JUN	0	1	0	37
JUL	0	1	0	37
AUG	0	1	0	37
SEP	0	1	0	37
OCT	0	1	0	37
NOV	59.23	.2	47.24	84.24
DEC	77.48	.13	67.08	104.08

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 36.9 GJ, OR 10249.44 KWHRS
ANNUAL SOLAR FRACTION = .2

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*     DIVISION OF BUILDING RESEARCH       *
*     SASKATOON, SASKATCHEWAN, 1982       *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 7

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	7.04		
TOTAL	100	7.04	14.2	12.21
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	16.26
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	2.25
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	6.61
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.91	3.99
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	8.5	6.91
FLOOR PERIMETER	36.52	0		
TOTAL	36.52	0	16.05	13.05
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	7.98	6.49
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	6.21
NORTH WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	4.39
EAST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	4.39
WEST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	4.39
AIR CHANGE	.22/HR	487.57 M3	33.09	28.05

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 5.34 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .72
EAST = .72 WEST = .72
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	58.42	.2	46.67	86.91
FEB	50.74	.29	36.17	76.41
MAR	43.26	.38	26.74	66.98
APR	24.26	.54	11.14	51.38
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	34.06	.34	22.39	62.63
DEC	47.46	.22	37.18	77.42

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 19.61 GJ, OR 5446.71 KWHRS
ANNUAL SOLAR FRACTION = .3

```
* * * * * * * * * * * * * * * * * * * * *
*                                       *
*            PROGRAM HOTCAN!            *
* NATIONAL RESEARCH COUNCIL OF CANADA   *
*    DIVISION OF BUILDING RESEARCH      *
*    SASKATOON, SASKATCHEWAN, 1982      *
*                                       *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 8

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	10.03
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	10.34
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.33
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	4.15
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	2.63
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	3.97
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	3.49
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	5.55
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	4.4
NORTH WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	2.99
EAST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	2.99
WEST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	2.99
AIR CHANGE	.5/HR	487.57 M3	75.2	45.15

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 7.27 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 17.8
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .72
EAST = .72 WEST = .72
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	90.1	.13	78.24	115.24
FEB	77.99	.2	62.58	99.58
MAR	66.96	.27	48.95	85.95
APR	39.9	.38	24.57	61.57
MAY	0	1	0	37
JUN	0	1	0	37
JUL	0	1	0	37
AUG	0	1	0	37
SEP	0	1	0	37
OCT	0	1	0	37
NOV	57.53	.21	45.55	82.55
DEC	75.51	.14	65.11	102.11

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 35.34 GJ. OR 9816.8 KWHRS
ANNUAL SOLAR FRACTION = .2

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*     DIVISION OF BUILDING RESEARCH       *
*     SASKATOON, SASKATCHEWAN, 1982       *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 9

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONA HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	13.42
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	13.84
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.78
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	5.55
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	3.53
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	5.31
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	4.67
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	7.43
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.89
NORTH WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	4
EAST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	4
WEST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	4
AIR CHANGE	.22/HR	487.57 M3	33.09	26.59

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 5.29 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .72
EAST = .72 WEST = .72
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	56.14	.21	44.4	84.64
FEB	47.86	.3	33.44	73.68
MAR	40.07	.4	23.88	64.12
APR	20.79	.59	8.46	48.7
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	32.36	.36	20.74	60.98
DEC	45.49	.23	35.22	75.46

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 18.07 GJ, OR 5020.75 KWHRS
ANNUAL SOLAR FRACTION = .31

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*     DIVISION OF BUILDING RESEARCH       *
*     SASKATOON, SASKATCHEWAN, 1982       *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 10

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	9.62
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	9.92
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.28
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	3.98
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	2.53
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	3.81
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	3.35
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	5.32
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	4.22
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	4.22
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	4.22
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	4.22
AIR CHANGE	.5/HR	487.57 M3	75.2	43.31

PROGRAM HOTCAN PAGE 2

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 7.61 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 17.8
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	95.26	.13	82.59	119.59
FEB	82.5	.2	65.92	102.92
MAR	70.94	.28	51.38	88.38
APR	42.56	.39	25.76	62.76
MAY	0	1	0	37
JUN	0	1	0	37
JUL	0	1	0	37
AUG	0	1	0	37
SEP	0	1	0	37
OCT	0	1	0	37
NOV	61.21	.21	48.44	85.44
DEC	80.01	.14	68.94	105.94

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 37.3 GJ, OR 10362.26 KWHRS
ANNUAL SOLAR FRACTION = .21

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*            PROGRAM HOTCAN!              *
* NATIONAL RESEARCH COUNCIL OF CANADA     *
*    DIVISION OF BUILDING RESEARCH        *
*    SASKATOON, SASKATCHEWAN, 1982        *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 11

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	12.7
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	13.1
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.69
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	5.26
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	3.34
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	5.03
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	4.42
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	7.03
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.57
NORTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.57
EAST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.57
WEST WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	5.57
AIR CHANGE	.22/HR	487.57 M3	33.09	25.16

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 5.62 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	61.3	.2	48.76	89
FEB	52.38	.3	36.79	77.03
MAR	44.05	.4	26.35	66.59
APR	23.46	.59	9.7	49.94
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	36.04	.35	23.6	63.84
DEC	49.99	.22	39.05	79.29

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 20.05 GJ. OR 5568.27 KWHRS
ANNUAL SOLAR FRACTION = .31

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*     DIVISION OF BUILDING RESEARCH       *
*     SASKATOON, SASKATCHEWAN, 1982       *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOMES-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 12

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONA HT LOSS
CEILING	100	10.57		
TOTAL	100	10.57	9.46	12.93
MAIN WALLS	84.94	8.45		
TOTAL	84.94	8.45	10.05	16.33
DOORS	3.9	2.47		
TOTAL	3.9	2.47	1.58	2.62
BASEMENT AB.GD.	24.35	7.04		
TOTAL	24.35	7.04	3.46	6.1
BASEMENT 600MM.	24.35	7.04		
TOTAL	24.35	7.04	3.26	3.83
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	9.58	11.25
FLOOR PERIMETER	36.52	1.76		
TOTAL	36.52	1.76	8.43	9.91
FLOOR CENTRE	63.48	1.76		
TOTAL	63.48	1.76	7.2	8.46
SOUTH WINDOWS	2.79	.38		
TOTAL	2.79	.38	7.33	8.98
NORTH WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	6.34
EAST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	6.34
WEST WINDOWS	2.79	.56		
TOTAL	2.79	.56	4.97	6.34
AIR CHANGE	.22/HR	487.57 M3	33.09	40.54

MODEL HOME -ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 4.31 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .72
EAST = .72 WEST = .72
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	39.96	.29	28.39	68.63
FEB	33.34	.4	20.01	60.25
MAR	27.06	.53	12.76	53
APR	0	1	0	40.24
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	20.45	.53	9.55	49.79
DEC	31.21	.32	21.13	61.37

HEATING SEASON STARTS IN NOV AND ENDS IN MAR.
ESTIMATED ANNUAL SPACE HEATING 10 GJ, OR 2777.44 KWHRS
ANNUAL SOLAR FRACTION = .4

```
* * * * * * * * * * * * * * * * * * * * *
*                                       *
*            PROGRAM HOTCAN!            *
* NATIONAL RESEARCH COUNCIL OF CANADA   *
*    DIVISION OF BUILDING RESEARCH      *
*    SASKATOON, SASKATCHEWAN, 1982      *
*                                       *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOME-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 11-A

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONA HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	12.7
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	13.1
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.68
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	5.26
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	3.34
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	5.03
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	4.42
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	7.03
SOUTH WINDOWS	6.55	.38		
TOTAL	6.55	.38	17.21	13.08
NORTH WINDOWS	1.39	.38		
TOTAL	1.39	.38	3.67	2.79
EAST WINDOWS	1.86	.38		
TOTAL	1.86	.38	4.89	3.72
WEST WINDOWS	1.36	.38		
TOTAL	1.36	.38	3.58	2.73
AIR CHANGE	.22/HR	487.57 M3	33.09	25.15

MODEL HOMES-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 10.35 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 17.8
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .5
FORCED VENTILATION RATE (AC/HR) = 0

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	145.74	.09	133.06	170.06
FEB	130.33	.13	112.95	149.95
MAR	114.33	.19	92.86	129.86
APR	75.42	.25	56.64	93.64
MAY	0	1	0	37
JUN	0	1	0	37
JUL	0	1	0	37
AUG	0	1	0	37
SEP	0	1	0	37
OCT	53.19	.29	38	75
NOV	96.38	.13	83.47	120.47
DEC	123.9	.09	112.83	149.83

HEATING SEASON STARTS IN OCT AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 68.56 GJ, OR 19045.48 KWHRS
ANNUAL SOLAR FRACTION = .15

PROGRAM HOTCAN PAGE 2

MODEL HOME-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 5.62 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	61.32	.28	44.14	84.38
FEB	52.4	.38	32.38	72.62
MAR	44.06	.47	23.52	63.76
APR	23.47	.61	9.24	49.48
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	36.05	.43	20.46	60.7
DEC	50	.3	34.77	75.01

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 17.9 GJ. OR 4973.04 KWHRS
ANNUAL SOLAR FRACTION = .38

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
* NATIONAL RESEARCH COUNCIL OF CANADA     *
*    DIVISION OF BUILDING RESEARCH        *
*    SASKATOON, SASKATCHEWAN, 1982        *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOME-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 11-B

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONA HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	12.7
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	13.1
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.68
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	5.26
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	3.34
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	5.03
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	4.42
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	7.03
SOUTH WINDOWS	1.36	.38		
TOTAL	1.36	.38	3.58	2.73
NORTH WINDOWS	1.86	.38		
TOTAL	1.86	.38	4.89	3.72
EAST WINDOWS	1.39	.38		
TOTAL	1.39	.38	3.67	2.79
WEST WINDOWS	6.55	.38		
TOTAL	6.55	.38	17.21	13.08
AIR CHANGE	.22/HR	487.57 M3	33.09	25.15

MODEL HOME-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 5.62 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	61.32	.18	50.32	90.56
FEB	52.4	.28	37.74	77.98
MAR	44.06	.4	26.47	66.71
APR	23.47	.61	9.2	49.44
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	36.05	.31	25.05	65.29
DEC	50	.19	40.54	80.78

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 20.6 GJ, OR 5721.57 KWHRS
ANNUAL SOLAR FRACTION = .29

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*     DIVISION OF BUILDING RESEARCH       *
*     SASKATOON, SASKATCHEWAN, 1982       *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOME-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 11-C

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	12.7
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	13.1
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.68
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	5.26
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	3.34
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	5.03
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	4.42
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	7.03
SOUTH WINDOWS	1.39	.38		
TOTAL	1.39	.38	3.67	2.79
NORTH WINDOWS	6.55	.38		
TOTAL	6.55	.38	17.21	13.08
EAST WINDOWS	1.86	.38		
TOTAL	1.86	.38	4.89	3.72
WEST WINDOWS	1.36	.38		
TOTAL	1.36	.38	3.58	2.73
AIR CHANGE	.22/HR	487.57 M3	33.09	25.15

MODEL HOME-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 5.62 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	61.32	.14	52.49	92.73
FEB	52.4	.23	40.11	80.35
MAR	44.06	.35	28.77	69.01
APR	23.47	.58	9.75	49.99
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	36.05	.24	27.52	67.76
DEC	50	.15	42.52	82.76

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 21.88 GJ. OR 6078.22 KWHRS
ANNUAL SOLAR FRACTION = .25

```
* * * * * * * * * * * * * * * * * * * * *
*                                         *
*              PROGRAM HOTCAN!            *
*  NATIONAL RESEARCH COUNCIL OF CANADA    *
*     DIVISION OF BUILDING RESEARCH       *
*     SASKATOON, SASKATCHEWAN, 1982       *
*                                         *
* * * * * * * * * * * * * * * * * * * * *
```

MODEL HOME-ALBERTA
LETHBRIDGE
DATA IS FOR SUFFIELD

RUN 11-D

*** BUILDING PARAMETERS ***

ELEMENT	AREA M2	RSI VALUE M2-DEGC/W	HT LOSS W/DEGC	% SEASONAL HT LOSS
CEILING	100	5.99		
TOTAL	100	5.99	16.7	12.7
MAIN WALLS	84.94	4.93		
TOTAL	84.94	4.93	17.23	13.1
DOORS	3.9	1.76		
TOTAL	3.9	1.76	2.22	1.68
BASEMENT AB.GD.	24.35	3.52		
TOTAL	24.35	3.52	6.91	5.26
BASEMENT 600MM.	24.35	3.52		
TOTAL	24.35	3.52	4.19	3.34
BASE. TO FLOOR	48.7	3.52		
TOTAL	48.7	3.52	6.31	5.03
FLOOR PERIMETER	36.52	1.32		
TOTAL	36.52	1.32	5.55	4.42
FLOOR CENTRE	63.48	0		
TOTAL	63.48	0	8.82	7.03
SOUTH WINDOWS	1.86	.38		
TOTAL	1.86	.38	4.89	3.72
NORTH WINDOWS	1.36	.38		
TOTAL	1.36	.38	3.58	2.73
EAST WINDOWS	6.55	.38		
TOTAL	6.55	.38	17.21	13.08
WEST WINDOWS	1.39	.38		
TOTAL	1.39	.38	3.67	2.79
AIR CHANGE	.22/HR	487.57 M3	33.09	25.15

MODEL HOME-ALBERTA
LETHBRIDGE

DESIGN HEAT LOSS AT -26.1C = 5.62 KW
TEMPERATURES (DEG C) MAIN FLOOR = 21 BASEMENT = 18
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 6.4
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 21.04
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 19.2
MASS LEVEL CHOSEN IS <A>
WINDOW SHADING COEFFICIENTS: SOUTH = .83 NORTH = .83
EAST = .83 WEST = .83
SOUTH OVERHANG GEOMETRY: AVERAGE WINDOW HEIGHT = 1.52 M
AVERAGE OVERHANG WIDTH = .61 M
AVERAGE HEIGHT ABOVE WINDOW = .2 M
NATURAL INFILTRATION RATE (AC/HR) = .1
FORCED VENTILATION RATE (AC/HR) = .4
HEAT RECOVERY EFFECTIVENESS ON VENTILATION AIR = 70%

*** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH	THERMAL LOAD KWH/D	MONTHLY SOLAR FRAC	AUX HEAT REQ KWH/D	TOT CONS KWH/D
JAN	61.32	.2	49.33	89.57
FEB	52.4	.29	36.99	77.23
MAR	44.06	.41	25.88	66.12
APR	23.47	.62	8.88	49.12
MAY	0	1	0	40.24
JUN	0	1	0	40.24
JUL	0	1	0	40.24
AUG	0	1	0	40.24
SEP	0	1	0	40.24
OCT	0	1	0	40.24
NOV	36.05	.33	24.21	64.45
DEC	50	.2	39.81	80.05

HEATING SEASON STARTS IN NOV AND ENDS IN APR.
ESTIMATED ANNUAL SPACE HEATING 20.14 GJ. OR 5593.82 KWHRS
ANNUAL SOLAR FRACTION = .31

FILE NAME: SUFFIELD

MONTHLY SOLAR RADIATION (MJ/M2-DAY):

MONTH	SOUTH	NORTH	EAST	WEST
1	12.688	2.197	4.75	4.728
2	15.788	3.303	7.436	7.529
3	17.06	4.47	10.631	10.676
4	13.389	4.725	11.868	11.539
5	11.721	6.613	14.372	13.322
6	10.772	8.186	15.102	14.09
7	12.274	7.414	15.92	15.451
8	14.189	5.074	14.388	13.74
9	15.2	3.382	10.767	10.906
10	15.545	2.448	7.678	7.446
11	13.249	1.89	4.855	4.967
12	11.666	1.694	3.92	4.003

TEMPERATURES (CELSIUS):

MONTH	AIR TEMPERATURE
1	-9.4
2	-5.6
3	-2.4
4	5.3
5	10.9
6	14.9
7	18.8
8	17.8
9	12.7
10	7.6
11	-.7
12	-5.0

DEEP GROUND TEMPERATURE (CELSIUS): 5.4

DESIGN TEMPERATURE DIFFERENCE (CELSIUS): 47.1

LATITUDE (DEGREES): 49.6

APPENDIX B2

ENVIRONMENTAL DATA

[redacted]
TEMPERATURE QUOTIDIENNE MOYENNE 1951-80

	JAN JAN	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNEE	CODE CODE
ALBERTA														
ALBERTA														
KANANASKIS BOUNDARY RS	-12.0	-8.3	-5.6	0.6	6.2	10.1	13.2	12.6	8.7	3.8	3.9	-0.9	1.4	0
KANANASKIS LO	M	M	M	M	M	7.5	11.4	10.4	6.3	M	M	M	M	0
KEANE LO	M	M	M	M	9.2	14.4	16.8	15.2	M	M	M	M	M	0
KEG RIVER	-22.6	-16.4	-9.7	1.7	9.5	13.8	15.7	14.1	9.0	2.8	0.8	17.3	0.7	2
KEG RIVER RS	M	M	M	1.3	8.5	12.8	14.9	13.2	8.1	M	M	M	M	0
KEG LO	M	M	M	M	7.4	11.6	13.8	12.3	6.9	M	M	M	M	0
KINSELLA RANCH	-16.9	-11.4	-6.9	3.2	10.4	14.2	16.7	15.6	10.4	4.9	-5.2	-12.4	1.9	0
KINUSO RS	-18.7	-12.4	-6.6	3.2	9.5	13.4	15.6	14.3	9.2	4.6	-6.0	-13.9	1.0	0
KISKA LO	M	M	M	M	M	7.4	10.5	9.8	5.6	M	M	M	M	0
KITSCOTY	-18.1	-12.9	-8.0	2.8	10.5	14.4	16.9	15.6	10.2	4.5	-5.8	-13.4	1.4	0
LAC LA BICHE	-18.4	-12.5	-7.3	2.1	9.9	14.3	17.0	15.7	10.1	4.7	-5.5	-13.7	1.4	0
LAC LA BICHE A	-18.7	-12.3	-7.2	3.2	10.1	14.0	16.1	14.7	9.4	4.4	-6.4	-14.6	1.1	0
LAC LA BICHE (AUT)	-18.7	-12.9	-7.2	3.2	9.7	13.9	16.1	14.7	9.3	4.6	-6.2	-14.2	1.0	0
LACOMBE CDA	-15.5	-10.5	-6.0	3.1	9.9	13.7	16.1	14.9	10.1	4.7	-4.4	-11.3	2.1	1
LA COREY RS	-21.0	-15.4	-9.7	1.9	9.8	13.6	16.0	14.5	8.9	3.4	-7.4	-15.8	-0.1	0
LAKE LOUISE	-15.2	-10.0	-6.7	-0.3	5.7	9.8	12.2	11.4	7.1	1.5	-7.7	-12.9	-0.4	1
LEGEND LO	M	M	M	M	7.3	11.8	13.8	12.4	6.7	M	M	M	M	0
[redacted]	-10.3	-5.4	-2.1	4.9	11.0	15.4	18.6	17.6	12.7	7.5	-0.8	-5.8	5.3	1
LETHBRIDGE CDA	-10.6	-5.7	-2.2	4.8	10.8	15.0	18.0	17.0	12.2	7.1	-1.0	-6.0	5.0	1
LIVINGSTONE LO	M	M	M	M	M	7.5	11.4	10.6	5.9	M	M	M	M	0
LIVOCK LO	M	M	M	M	9.2	13.1	15.3	14.0	M	M	M	M	M	0
LLOYDMINSTER	-18.2	-13.2	-7.9	2.9	10.8	14.8	17.5	16.1	10.4	4.4	-5.8	-12.5	1.6	0
LLOYDMINSTER NORTH	-18.2	-12.8	-7.7	3.0	10.8	14.4	16.9	15.4	10.2	4.7	-5.8	-13.3	1.5	0
LOVETT LO	M	M	M	M	6.6	10.3	12.9	12.3	8.0	M	M	M	M	0
LYNDON	-10.0	-5.6	-3.2	3.0	8.7	12.4	15.6	14.7	10.3	6.1	-1.2	-6.3	3.7	0
MAGRATH	-9.6	-4.6	-1.7	4.7	10.8	14.9	18.3	17.4	12.5	7.6	-0.9	-5.2	5.4	0
MANNING RS	M	M	M	M	10.1	14.2	16.3	14.6	9.7	3.9	M	M	M	0
MANYBERRIES CDA	-13.2	-9.0	-4.4	4.3	11.0	15.5	19.3	18.4	12.4	6.4	-2.8	-8.7	4.1	1
MARTEN MOUNTAIN LO	M	M	M	M	8.2	12.3	14.3	13.0	7.8	3.4	M	M	M	0
MARWAYNE	-18.8	-13.4	-8.3	3.0	10.7	14.2	16.6	15.2	9.7	4.1	-6.6	-13.8	1.1	0
MAYBERNE LO	M	M	M	M	8.4	10.2	12.8	11.8	7.3	3.0	M	M	M	0
MAY LO	M	M	M	M	8.6	12.8	15.1	13.6	7.8	M	M	M	M	0
MCLENNAN CDA EPF	-18.9	-12.9	-7.5	2.4	10.1	13.7	15.9	14.5	9.4	3.9	-6.3	-13.8	0.9	0
MCLENNAN RS	M	M	M	2.7	10.0	13.6	15.7	14.5	9.4	4.5	M	M	M	0
MEANOOK	-16.0	-11.0	-6.0	3.1	10.4	14.1	16.6	15.2	9.8	4.9	-5.4	-11.8	2.0	3
MEDICINE HAT A	-12.6	-7.7	-2.8	5.6	12.3	16.6	19.9	18.9	13.2	7.4	-1.6	-7.6	5.1	1
MERIDIAN LO	M	M	M	M	8.1	12.3	14.5	13.1	7.7	M	M	M	M	0
MILK RIVER	-10.8	-5.6	-1.8	4.8	11.0	15.4	18.9	17.9	12.5	7.3	-0.9	-6.1	5.2	0
MOBERLY LO	M	M	M	M	M	8.5	11.3	10.6	6.2	M	M	M	M	0
MOCKINGBIRD LO	M	M	M	M	5.5	9.4	12.7	11.9	7.7	M	M	M	M	0
MOON LAKE	-15.8	-9.7	-5.5	3.1	9.5	13.0	15.4	14.3	9.4	4.1	-5.0	-11.8	1.8	0
MOUNT EISENHOWER	M	M	M	M	6.3	9.3	12.3	11.4	7.6	M	M	M	M	0
MUSKEG LO	M	M	M	M	8.2	13.0	15.3	13.7	7.6	M	M	M	M	0
MUSKWA LO	M	M	M	M	9.8	13.3	15.6	13.9	8.8	M	M	M	M	0
NACO	-17.2	-12.6	-7.7	2.9	10.2	14.3	17.2	16.1	10.3	4.5	-5.1	-12.5	1.7	0
NAYLOR HILLS LO	M	M	M	M	9.0	13.0	14.9	13.1	8.0	M	M	M	M	0
NEWBROOK	-18.2	-13.5	-7.7	2.3	9.5	13.2	15.2	13.9	9.1	3.8	-7.2	-14.2	0.5	3
NORDEGG RS	-14.1	-8.2	-5.8	0.7	6.3	9.8	12.6	11.6	7.3	2.8	-4.9	-10.1	0.7	0
NOSE MOUNTAIN LO	M	M	M	M	M	9.4	11.8	11.1	7.2	M	M	M	M	0
NOTIKEWIN LO	M	M	M	M	8.2	12.1	14.3	12.9	8.1	M	M	M	M	0
NOTIKEWIN EAST	-22.6	-16.4	-10.7	1.4	9.7	13.8	15.8	14.1	8.8	2.6	-8.9	-17.5	-0.8	0
OBED LO	M	M	M	M	5.1	9.3	11.8	11.2	6.7	2.3	M	M	M	0
O CHIESE LO	M	M	M	M	9.1	12.6	15.0	14.1	9.4	M	M	M	M	0
OLDS	-13.2	-8.5	-5.3	2.9	9.3	13.2	15.7	14.7	10.2	5.1	-3.4	-8.8	2.7	1
OLIVER TREE NURSERY	-17.3	-11.7	-6.3	3.5	10.7	14.4	16.7	15.4	10.3	4.8	-4.9	-12.4	1.9	0
OTTER LAKES LO	M	M	M	M	9.0	12.7	14.9	13.2	7.9	M	M	M	M	0
OYEN CAPPON	-15.8	-11.0	-5.9	3.6	10.7	15.1	17.6	16.5	11.3	5.4	-5.1	-10.8	2.6	0
PANNY LO	M	M	M	M	M	13.2	15.1	13.7	M	M	M	M	M	0
PASS CREEK LO	M	M	M	M	8.1	11.8	14.2	13.0	8.6	M	M	M	M	0
PEACE RIVER A	-20.4	-13.5	-6.5	2.1	9.6	13.7	15.7	14.2	9.1	3.7	-8.1	-15.3	0.2	2
PEAVINE	-15.8	-9.9	-5.3	3.4	10.3	13.7	16.0	14.8	10.0	5.1	-4.7	-11.7	2.2	0
PEKISKO	-11.1	-7.0	-5.3	0.9	6.6	10.3	13.2	12.3	8.4	4.2	-3.1	-7.4	1.8	0
PELICAN MOUNTAIN LO	M	M	M	M	8.1	12.5	14.6	13.1	7.7	M	M	M	M	0

Acknowledgements

This series of publications is dedicated to the hundreds of volunteer weather observers across Canada. Publication of any climate normals involves many persons beginning with those who made the original observations. Years of faithful and accurate weather observing are required to generate the data from which normals may be calculated. For example, it takes almost 22,000 separate observations to calculate an annual normal for one station.

Quality control, archiving, computer programming and publishing are just a few of the other tasks that must be performed. D.W. Phillips coordinated the project to produce the 1951-1980 normals and long period abstracts; D. Aston prepared program and data specifications and designed publication layouts; Mrs. J. Blackburn and F. Yates supervised the writing of several programs; Y. Durocher developed the data adjustment technique and W. Johnson designed the cover.

Code	
	complete 30 years
.	25 to 29 years
,	20 to 24 years
;	15 to 19 years
:	10 to 14 years
-	less than 10 years but more than 4 years
=	not assigned
~	adjusted normals based on 5 to 19 years, inclusive, from 1951 to 1980 and any other available data from 1931 to 1950

EXTREME MINIMUM TEMPERATURE
TEMPERATURE MINIMALE EXTREME

	JAN JAN	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNEE
ALBERTA													
ALBERTA													
LAC LA BICHE A	-42.0	-46.1	-34.4	-24.4	-8.3	-1.0	0.0	-1.1	-7.8	-11.7	-35.6	-45.6	-46.1
YEARS ANNEES	7	6	8	8	8	8	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LAC LA BICHE (AUT)	-48.3	-46.7	-44.4	-22.8	-11.7	-3.3	2.2	-2.2	-8.3	-15.0	-40.0	-40.6	-48.3
YEARS ANNEES	14	15	13	14	15	13	13	[illegible]	[illegible]	15	15	[illegible]	
LACOMBE CDA	-48.9	-45.0	-41.1	-32.2	-12.2	-5.6	-1.1	-1.9	-14.4	-24.4	-37.2	-49.4	-49.4
YEARS ANNEES	73	73	73	73	73	60	71	[illegible]	[illegible]	[illegible]	73	[illegible]	
LA COREY RS	-50.0	-42.8	-42.8	-22.2	-10.6	-4.4	-0.6	-3.3	-12.2	-18.9	-35.0	-46.1	-50.0
YEARS ANNEES	6	5	6	6	15	13	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
LAKE LOUISE	-52.8	-50.6	-44.4	-33.9	-27.8	-10.0	-5.6	-7.2	-25.0	-30.6	-43.3	-49.4	-52.8
YEARS ANNEES	63	64	[illegible]	61	63	61	62	[illegible]	[illegible]	61	[illegible]	[illegible]	
LEGEND LO	M	M	M	M	-13.3	-6.7	-1.0	-2.2	-13.3	-14.4	M	M	M
YEARS ANNEES	0	[illegible]	0	0	16	[illegible]	19	19	8	4	0	[illegible]	
[redacted]	-42.8	-42.2	-37.8	-25.6	-11.7	-1.7	1.7	0.0	-9.4	-21.7	-33.9	-42.8	-42.8
YEARS ANNEES	43	43	43	43	43	43	43	43	43	43	43	[illegible]	
LETHBRIDGE CDA	-42.8	-41.1	-37.8	-27.2	-12.8	-3.3	0.0	-1.7	-15.6	-26.1	-35.6	-42.8	-42.8
YEARS ANNEES	72	72	73	73	73	73	73	73	73	73	73	[illegible]	
LIVINGSTONE LO	M	M	M	M	-7.0	-7.8	-3.9	-8.1	-12.8	-12.8	M	M	M
YEARS ANNEES	0	0	0	0	1	17	17	17	17	1	0	[illegible]	
LIVOCK LO	M	M	M	-17.2	-8.0	-1.1	0.0	-0.6	-10.0	M	M	M	M
YEARS ANNEES	0	0	0	1	6	14	15	13	1	0	0	0	
LLOYDMINSTER	-46.1	-39.4	-36.1	-28.9	-16.7	-6.7	-4.4	-5.0	-12.2	-23.3	-32.2	-42.8	-46.1
YEARS ANNEES	19	16	19	40	40	39	39	38	42	38	20	[illegible]	
LLOYDMINSTER NORTH	-42.2	-36.1	-36.7	-25.6	-5.6	0.6	3.3	-0.6	-8.3	-14.4	-25.0	-37.2	-42.2
YEARS ANNEES	5	5	5	6	6	6	6	5	5	5	5	[illegible]	
LOVETT LO	M	M	M	M	-9.4	-3.3	-1.1	-3.9	-13.3	-13.9	M	M	M
YEARS ANNEES	0	0	0	0	14	23	23	23	23	8	0	0	
LYNDON	-36.1	-35.0	-33.9	-18.9	-10.0	-3.3	-1.1	-1.1	-8.3	-18.3	-32.2	-36.3	-36.3
YEARS ANNEES	9	9	9	8	8	8	8	8	8	8	9	9	
MAGRATH	-43.3	-34.4	-36.9	-17.8	-12.2	-0.6	1.7	0.0	-5.0	-18.9	-30.0	-36.7	-43.3
YEARS ANNEES	10	9	6	13	16	15	15	15	14	[illegible]	[illegible]	[illegible]	
MANNING RS	-38.4	-44.4	-33.3	-23.9	-8.7	-5.8	-1.1	-1.1	-12.8	-11.1	-33.3	-27.8	-44.4
YEARS ANNEES	1	1	1	7	15	15	16	15	14	6	1	1	
MANYBERRIES CDA	-42.8	-42.8	-35.6	-26.1	-13.3	-1.7	1.1	0.6	-12.2	-23.9	-34.0	-41.1	-42.8
YEARS ANNEES	52	52	51	52	52	52	52	52	53	53	[illegible]	[illegible]	
MARTEN MOUNTAIN LO	M	M	M	-18.9	-8.3	-1.1	2.8	0.0	-11.7	-12.2	M	M	M
YEARS ANNEES	0	0	0	2	17	18	18	18	[illegible]	[illegible]	1	[illegible]	
MARWAYNE	-47.8	-41.1	-38.3	-26.1	-7.8	-3.9	0.0	-4.4	-6.7	-16.7	-37.0	-49.4	-49.4
YEARS ANNEES	[illegible]	[illegible]	[illegible]	11	12	13	[illegible]	13	[illegible]	[illegible]	[illegible]		
MAYBERNE LO	M	M	M	-17.2	-10.6	-3.9	-0.6	-3.9	-12.2	-16.1	M	M	M
YEARS ANNEES	0	0	[illegible]	1	26	24	22	24	25	14			
MAY LO	M	M	M	M	-10.6	-2.2	2.0	-1.1	-11.7	-4.4	M	M	M
YEARS ANNEES	0	0	0	0	13	15	16	16	[illegible]	[illegible]	0		
MCLENNAN CDA EPF	-46.1	-42.8	-41.1	-25.6	-9.4	0.0	3.3	-1.1	-8.3	-17.2	-35.6	-43.3	-46.1
YEARS ANNEES	[illegible]	[illegible]	[illegible]	10	10	10	10	[illegible]	10	10	[illegible]	[illegible]	
MCLENNAN RS	M	M	M	-16.7	-12.2	-1.1	1.1	-1.1	-8.9	-13.9	M	M	M
YEARS ANNEES	[illegible]	0	0	3	16	15	16	16	15	4	[illegible]		
MEANOOK	-42.2	-43.9	-37.2	-24.4	-13.9	-2.8	0.0	-0.6	-10.0	-22.8	-35.0	-40.6	-43.9
YEARS ANNEES	[illegible]	[illegible]	[illegible]	[illegible]	44	[illegible]	42	43	[illegible]	[illegible]	[illegible]	[illegible]	
MEDICINE HAT A	-46.1	46.1	-38.9	-26.7	-11.1	-1.1	2.2	-0.6	12.8	-23.3	37.8	-45.6	-46.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
METHAN LO	M	M	M	20.8	8.3	4.4	1.1	1.7	11.7	11.1	M	M	M
[illegible]	[illegible]	0	0	1	14	15	16	[illegible]	[illegible]	[illegible]			
MILK RIVER	37.2	-33.3	-33.3	-20.0	-8.3	0.0	2.2	2.2	-11.1	-18.3	-27.2	-40.6	-40.6
[illegible]	[illegible]	19	20	19	19	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
MOBERLY LO	M	M	M	M	-8.0	-2.8	-1.7	-5.0	-12.8	-8.3	M	M	M
YEARS ANNEES	[illegible]	0	0	0	6	13	14	14	13	[illegible]		[illegible]	

TEMPERATURE MAXIMALE EXTREME

	JAN JAN	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNEE
ALBERTA													
ALBERTA													
LAC LA BICHE A	9.5	12.8	12.8	28.0	29.0	31.1	31.7	29.4	27.0	27.5	17.8	11.0	31.7
YEARS ANNEES	7	7	8	8	8	8	8	8	7	8	9	8	
LAC LA BICHE (AUT)	11.7	13.9	17.2	24.4	30.0	33.9	32.8	31.1	30.0	27.2	14.4	11.7	33.9
YEARS ANNEES	14	14	13	14	13	13	13	13	14	15	15	15	
LACOMBE CDA	15.6	17.8	20.6	30.6	33.3	37.8	38.3	36.7	35.0	32.2	23.3	17.8	38.3
YEARS ANNEES	73	73	73	72	73	60	73	73	73	73	72	74	
LA COREY RS	9.4	9.4	13.3	24.4	31.7	33.3	34.4	32.2	32.2	25.6	13.9	6.1	34.4
YEARS ANNEES	6	6	6	7	15	11	13	14	14	13	8	6	
LAKE LOUISE	7.8	13.9	15.6	28.1	31.7	31.1	34.4	32.2	28.3	26.1	18.3	12.2	34.4
YEARS ANNEES	63	64	57	62	63	61	62	63	63	62	63	64	
LEGEND LO	M	M	M	17.8	27.8	28.3	30.6	29.4	23.9	21.1	6.1	M	30.6
YEARS ANNEES	0	0	0	1	18	18	19	19	9	5	1	0	
[illegible]	16.7	18.9	23.3	31.1	32.8	38.3	39.4	38.3	36.7	31.7	22.8	18.3	39.4
YEARS ANNEES	43	43	43	43	45	45	45	43	43	43	43	43	
LETHBRIDGE CDA	17.8	20.0	24.4	31.1	33.3	35.6	37.8	36.1	36.1	30.0	23.3	19.4	37.8
YEARS ANNEES	72	72	73	73	73	71	73	73	73	73	73	73	
LIVINGSTONE LO	M	M	M	17.2	22.2	25.6	30.6	28.3	24.4	21.1	M	M	30.6
YEARS ANNEES	0	0	0	1	8	17	16	17	14	6	0		
LIVOCK LO	M	M	M	M	28.9	29.0	31.0	31.1	27.2	M	M	M	31.1
YEARS ANNEES	0	0	0	0	9	13	15	14	2	0	0	0	
LLOYDMINSTER	10.0	11.1	15.0	32.8	36.7	37.8	37.2	37.2	35.0	28.9	16.1	10.0	37.8
YEARS ANNEES	20	17	19	42	40	39	40	40	43	38	21	20	
LLOYDMINSTER NORTH	6.1	8.3	11.1	23.9	33.3	33.3	33.3	33.3	26.7	25.6	18.3	7.2	33.3
YEARS ANNEES	5	5	5	6	6	6	6	5	5	5	5	5	
LOVETT LO	M	M	M	17.2	27.8	30.6	30.6	30.6	29.4	24.4	11.1	M	30.6
YEARS ANNEES	0	0	0	2	21	22	23	23	23	8	1	0	
LYNDON	16.7	17.8	22.2	34.4	27.8	31.7	35.6	33.3	29.4	27.8	20.0	16.1	35.6
YEARS ANNEES	9	9	9	8	8	8	8	8	8	8	8	9	
MAGRATH	16.1	18.3	21.1	28.9	32.2	33.3	36.1	37.2	32.8	29.4	22.8	16.1	37.2
YEARS ANNEES	10	9	9	13	16	16	15	15	14	8	8	10	
MANNING RS	7.2	6.7	4.4	25.0	31.1	33.9	34.4	33.0	29.4	23.9	13.9	8.3	34.4
YEARS ANNEES	1	1	1	11	15	15	16	15	13	8	1	1	
MANYBERRIES CDA	18.1	18.4	22.8	32.2	34.4	40.6	39.4	40.6	36.1	32.8	22.2	17.2	40.6
YEARS ANNEES	52	52	51	52	52	53	53	53	53	53	53	53	
MARTEN MOUNTAIN LO	M	M	M	21.1	27.2	30.0	30.0	28.9	25.6	23.9	9.4	M	30.0
YEARS ANNEES	0	0	0	6	17	18	18	18	17	14	1	0	
MARWAYNE	10.0	9.4	15.6	31.7	33.9	36.7	33.3	35.0	31.0	28.0	18.3	7.8	36.7
YEARS ANNEES	10	11	11	11	13	13	1	13	13	14	13	11	
MAYBERNE LO	M	M	M	20.6	27.2	29.4	27.8	30.0	25.6	23.3	8.9	M	30.0
YEARS ANNEES	0	0	0	7	26	26	27	23	24	16	1	0	
MAY LO	M	M	M	16.7	27.8	30.6	30.0	29.4	26.7	21.1	M	M	30.6
YEARS ANNEES	0	0	0	3	16	16	16	15	15	5	0	0	
MCLENNAN CDA EPF	10.0	12.8	15.0	29.4	34.4	32.8	30.0	31.1	26.7	23.3	14.5	7.2	34.4
YEARS ANNEES	11	11	11	10	10	10	10	11	10	10	11	11	
MCLENNAN RS	M	M	M	22.5	30.0	30.0	31.7	32.2	28.9	25.6	M	M	32.2
YEARS ANNEES			0	10	16	16	16	16	15	7			
MEANOOK	15.0	16.7	18.9	30.6	32.2	33.3	35.7	32.8	31.7	26.1	18.3	12.2	35.7
YEARS ANNEES	44	45	43	44	44	45	42	44	44	43	44	44	
MEDICINE HAT A	18.9	18.3	28.9	35.6	37.2	41.7	42.2	41.1	37.8	33.9	24.4	20.0	42.2
YEARS ANNEES	96	96	97	97	97	97	97	96	98	97	96	96	
MERIDIAN LO	M	M	M	20.0	28.3	30.6	30.0	28.3	26.1	21.7	M	M	30.6
YEARS ANNEES			0	5	15	16	16	16	14	7			
MILK RIVER	13.3	18.3	23.3	28.9	31.7	35.6	37.8	41.1	35.6	32.8	22.8	16.1	41.1
YEARS ANNEES	20	20	20	19	19	18	19	19	19	18	20	20	
MOBERLY LO	M	M	M	M	25.0	27.2	27.8	28.3	25.6	21.7	M	M	28.3
YEARS ANNEES			0	0	9	13	14	14	12	2			

DIRECTION DOMINANTE ET VITESSE MOYENNE (km/h) DU VENT

ALBERTA ALBERTA	JAN JAN	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOÛT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNEE	CODE CODE
BIGHORN DAM	10.8 SW	13.8 SW	12.7 SW	12.2 SW	9.7 SW	11.6 SW	10.8 SW	7.4 SW	10.6 SW	14.6 SW	14.7 SW	15.1 SW	11.9 SW	6
BROOKS	13.2 NW	12.6 NW	13.4 NW	16.0 NW	14.9 NW	13.9 NW	12.3 NW	12.1 NW	12.5 NW	14.1 SW	13.6 S	13.6 SW	13.5 NW	5
CALGARY INT'L A	16.2 W	15.8 S	16.4 S	18.1 NNW	18.2 NNW	17.0 NNW	14.9 NNW	14.4 NNW	15.8 NNW	16.3 W	15.4 W	16.1 W	16.2 W	2
COLD LAKE A	11.9 W	11.9 F	12.9 F	14.8 E	15.7 E	14.4 W	13.5 W	12.7 W	14.2 W	14.5 W	13.3 W	12.0 W	13.5 W	2
CORONATION A	16.3 NNW	15.7 NNW	15.7 NNW	16.5 NNW	16.9 NNW	16.0 NW	14.7 NW	14.5 NW	16.1 NNW	16.4 S	15.9 S	16.1 NW	15.9 NNW	3
COWLEY A	19.5 N	19.1 N	19.1 W	18.9 N	17.6 N	18.1 N	15.8 N	16.0 N	17.5 N	20.7 SW	22.2 N	24.9 SW	19.1 S	6
EDMONTON INT'L A	13.4 S	13.4 S	13.4 S	15.2 S	15.7 SE	13.6 W	11.8 W	11.3 W	13.0 S	13.6 S	12.9 S	13.1 S	13.4 S	3
EDMONTON MUNICIPAL A	13.0 S	13.0 S	13.8 S	15.5 S	16.1 S	15.4 WNW	14.0 WNW	13.4 S	14.6 S	14.3 S	13.5 S	13.0 S	14.1 S	2
EDMONTON NAMAO A	16.2 W	16.3 W	16.4 E	17.9 S	18.8 WNW	17.3 W	15.5 W	15.0 W	16.8 W	17.3 W	16.4 W	16.7 WSW	16.7 W	2
EDMONTON STONY PLAIN	11.1 NW	11.0 W	11.1 NW	12.3 NW	12.5 NW	11.8 NW	10.5 NW	10.0 NW	10.8 NW	11.9 NW	11.0 NW	11.3 N	11.3 NW	5
EDSON	8.7 WSW	9.7 W	11.4 NE	12.1 WSW	11.6 W	10.9 W	10.2 W	8.7 W	10.4 W	9.8 W	9.2 W	8.7 WSW	10.2 W	5
EDSON A	8.0 W	8.1 W	8.0 W	8.8 W	9.2 W	9.2 W	8.8 W	7.2 W	7.4 W	7.9 W	7.1 W	7.0 W	8.0 W	5
ELLERSLIE	12.4 NW	12.5 SE	12.4 SE	13.7 SE	13.4 NW	13.1 NW	11.8 NW	11.4 SE	13.0 NW	13.4 SE	12.3 SE	12.4 S	12.7 NW	6
EMBARRAS A	10.3 SSE	9.7 NW	10.1 SE	11.8 SE	12.3 NNE	11.1 SSE	10.9 W	10.4 S	11.9 S	12.3 S	11.4 S	10.3 SSE	11.0 SE	6
FAIRVIEW	10.4 NW	11.4 E	11.3 E	12.2 E	13.3 NW	11.8 NW	10.6 W	10.1 NW	10.7 NW	12.2 W	10.5 NW	10.3 NW	11.2 NW	4
FORT CHIPEWYAN	10.8 WNW	11.6 E	12.0 E	12.8 E	14.2 ENE	14.3 ENE	12.5 ENE	12.6 WSW	12.8 NNW	13.1 WSW	12.0 W	9.9 E	12.4 E	6
FORT CHIPEWYAN A	8.5 W	8.5 E	9.6 E	10.5 E	12.4 E	11.0 E	9.9 W	9.4 W	10.5 W	9.9 W	9.2 W	8.3 E	9.8 E	5
FORT MCMURRAY A	8.6 E	9.1 E	9.9 E	11.2 ESE	11.4 E	9.8 E	9.2 W	8.9 SW	9.6 W	10.6 E	9.3 E	8.4 E	9.7 E	2
FORT VERMILION CDA	7.5 W	8.1 E	9.1 E	10.0 E	9.5 SE	7.9 NW	7.3 NW	6.9 NW	8.0 NW	9.2 E	8.3 E	7.6 E	8.2 E	5
GRANDE PRAIRIE A	11.5 NW	12.3 NW	12.8 NW	14.5 W	16.8 W	16.2 W	14.1 W	13.6 W	13.7 W	14.4 W	12.0 W	11.3 NW	13.6 W	2
HIGH LEVEL A	5.9 N	6.3 N	8.0 N	9.4 N	8.7 N	8.0 N	6.9 N	6.8 N	7.2 N	7.6 SE	6.0 N	5.0 N	7.2 N	5
JASPER	10.3 SW	9.7 SW	10.0 SW	9.7 SW	9.3 SW	8.9 SW	8.3 SW	8.3 SW	8.4 SW	9.6 SW	9.6 SW	10.2 SW	9.4 SW	5
KANANASKIS	9.7 SW	10.5 SW	10.1 SW	9.2 SW	8.8 SW	9.1 SW	8.5 SW	7.7 SW	8.0 SW	11.1 SW	11.2 SW	10.9 SW	9.6 SW	5
KAYBOB 3	10.6 W	11.1 SW	10.7 SW	10.7 SW	11.3 NW	10.2 SW	9.5 W	9.3 NW	8.4 S	13.9 SW	10.9 SW	13.0 NW	10.8 SW	6
KEG RIVER	8.5 W	9.2 NW	9.9 NW	10.7 NW	11.9 SW	11.0 SW	8.9 NW	8.4 NW	9.5 NW	12.3 W	8.5 W	8.5 W	9.8 W	6
LAC LA BICHE (AUT)	8.3 NW	8.8 S	10.0 SE	11.0 S	11.7 NW	10.4 W	9.4 W	8.3 W	10.0 W	11.1 W	10.0 W	9.2 W	10.0 W	-
LACOMBE CDA	10.1	9.8	10.5	12.5	13.5 NW	11.7 NW	10.3 NW	10.0 NW	10.5	11.2	10.1	10.0	10.9	4
[redacted]	21.2 W	21.1 W	21.0 W	21.3 W	20.4 W	20.0 W	16.9 W	16.8 W	18.4 W	22.5 W	22.4 W	23.1 W	20.4 W	-

LETHBRIDGE A ALTA

PERIOD 1955-80 PERIODE

Lat 49 38 N Long 112 48 W

Elevation 929 m Altitude

	JAN JANV	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC	YEAR ANNUEL	
[redacted]													FREQUENCE EN %	
N	5.6	6.2	6.3	7.2	6.4	4.7	4.6	5.	6.0	4.4	4.9	5.2	5.5	N
NNE	4.0	3.5	3.4	3.8	3.5	3.2	3.0	3.1	2.6	2.2	2.9	2.9	3.2	NNE
NE	4.3	4.4	3.7	4.1	3.9	3.6	3.5	3.4	2.9	2.7	2.5	3.3	3.5	NE
ENE	2.8	2.8	2.7	2.7	3.0	2.4	3.2	3.0	2.4	1.4	2.0	2.0	2.6	ENE
E	3.3	3.9	3.5	3.6	4.3	3.5	4.6	4.2	3.2	1.8	2.5	2.3	3.4	E
ESE	2.0	2.0	2.1	2.7	2.8	2.4	2.8	2.9	2.3	1.6	1.5	1.4	2.2	ESE
SE	2.3	3.2	3.2	4.1	4.9	4.0	4.6	4.0	3.7	2.7	2.2	1.8	3.4	SE
SSE	1.7	1.7	2.3	2.9	3.6	3.0	3.4	2.8	2.9	2.1	1.9	1.7	2.5	SSE
S	3.8	3.8	5.1	5.2	5.4	5.1	5.3	4.8	5.8	5.6	5.3	4.0	4.9	S
SSW	4.5	4.5	6.1	5.2	4.5	4.7	5.3	5.0	5.9	6.6	6.1	5.1	5.3	SSW
SW	10.7	10.3	12.3	10.7	9.7	10.5	11.1	10.5	12.2	13.8	13.0	12.2	11.4	SW
WSW	17.9	17.0	15.8	14.4	13.1	15.3	14.1	14.1	14.3	19.2	18.4	19.5	16.1	WSW
W	19.3	18.5	16.9	17.0	16.7	19.9	17.1	17.0	17.1	21.8	21.5	21.0	18.6	W
WNW	4.4	4.5	4.8	4.6	5.4	6.0	4.1	4.9	5.0	4.0	4.3	4.5	4.9	WNW
NW	4.2	4.1	4.3	4.7	5.9	5.4	5.0	5.4	5.6	3.9	4.2	4.6	4.8	NW
NNW	3.3	3.3	3.7	4.3	4.3	3.5	3.0	3.5	4.3	3.3	3.1	3.6	3.6	NNW
Calm	5.9	6.3	3.9	2.6	2.8	2.8	4.4	4.4	3.8	3.7	3.9	4.9	4.1	Calme

[redacted] MEAN WIND SPEED IN KILOMETRES PER HOUR

VITESSE MOYENNE DES VENTS EN KILOMETRES PAR HEURE

N	16.8	17.6	19.5	20.4	19.0	17.1	15.5	15.4	16.6	17.4	17.4	17.3	17.8	N
NNE	14.1	13.8	16.3	18.7	18.6	17.6	14.9	14.0	15.4	15.3	14.8	12.5	15.6	NNE
NE	12.2	12.8	13.2	16.5	17.2	15.9	13.0	12.5	13.7	13.6	14.0	12.2	13.9	NE
ENE	11.6	11.9	12.5	15.0	16.3	14.2	13.0	13.0	11.2	11.5	11.6	11.4	12.8	ENE
E	10.6	11.2	11.9	13.6	14.9	13.4	11.4	10.9	10.8	10.2	9.8	10.3	11.6	E
ESE	11.9	12.6	13.6	14.7	15.7	14.9	12.5	12.0	11.4	11.4	10.8	11.9	12.8	ESE
SE	10.4	12.1	13.7	15.9	16.1	15.0	13.2	13.1	12.7	13.4	11.2	11.9	13.2	SE
SSE	11.2	11.9	13.5	15.1	17.5	15.9	14.0	13.5	12.9	13.1	12.0	10.8	13.5	SSE
S	13.8	14.0	15.1	16.5	18.0	15.3	14.3	13.0	14.1	15.4	15.1	13.4	14.7	S
SSW	18.4	17.8	19.5	19.0	16.8	16.5	15.6	14.1	16.5	18.2	18.6	17.7	17.4	SSW
SW	23.0	22.7	22.8	21.3	20.1	19.4	17.8	17.7	18.5	22.4	23.1	23.5	21.0	SW
WSW	33.4	33.8	30.5	29.7	28.0	27.2	22.5	23.4	24.9	31.1	31.3	34.2	29.2	WSW
W	32.3	33.0	30.3	30.3	28.5	27.3	23.7	23.4	26.1	31.6	32.9	34.7	29.5	W
WNW	14.5	15.2	16.8	17.9	18.1	18.5	16.8	17.0	16.6	16.3	16.0	15.9	16.6	WNW
NW	14.5	14.8	16.0	17.1	17.8	17.3	16.2	15.9	17.2	16.5	15.8	15.1	16.2	NW
NNW	18.5	18.6	20.4	21.0	19.9	17.7	17.3	16.0	19.6	20.3	19.1	20.5	19.0	NNW
All Directions													Toutes directions	
	21.2	21.1	21.0	21.3	20.4	20.0	16.9	16.8	17.4	20.[illegible]	[illegible]	20.1	20.4	
Maximum Hourly Speed													Vitesse horaire maximale	
	109 W	100 WSW	100 WSW	97 W	113 W	97 SW	89 W	87 WSW	96 WSW	[illegible] W	[illegible] W	104 W	121 WSW	
Maximum Gust Speed													Vitesse maximale des rafales	
	140 WSW	143 WSW	138 SW	138 WSW	148 WSW	137 WSW	122 W	122 WSW	124 WSW	[illegible] W	[illegible] W	148 WSW	[illegible] W	

Height of anemometer 10.1 m Hauteur de l'anemometre

STATION INFORMATION

Airport located 8 km south of city on generally flat farmland. Location in lee of Rocky Mountains 80-100 km west. Moderate-strong (chinook) winds occur especially during fall and winter.

DONNEES RELATIVES A LA STATION

L'aeroport se trouve a 8 km au sud de la ville sur des terres [illegible] en general plates sous le vent des Rocheuses qui se trouvent entre 80 et 100 km a l'ouest. On enregistre des vents moderes a forts (chinook) particulierement durant l'automne et l'hiver.

MEAN HOURLY NET RADIATION ON A HORIZONTAL SURFACE (RF-4)
MOYENNE HORAIRE DU BILAN DU RAYONNEMENT SUR UNE SURFACE HORIZONTALE (RF-4)

[illegible]/Heure

[illegible]	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
JAN/JAN	-0.14	-0.14	-0.14	-0.14	-0.13	-0.13	-0.12	-0.12	-0.07	0.01	0.08	0.12	0.11	0.06	-0.02	-0.11	-0.16	-0.16	-0.15	-0.14	-0.14	-0.14	-0.14	-0.14
FEB/FÉV	-0.14	-0.14	-0.13	-0.13	-0.13	-0.13	-0.13	-0.08	0.03	0.17	0.30	0.37	0.37	0.31	0.19	0.02	-0.11	-0.16	-0.16	-0.15	-0.15	-0.14	-0.14	-0.13
MAR/MARS	-0.17	-0.16	-0.16	-0.16	-0.16	-0.16	-0.10	0.09	0.36	0.58	0.76	0.84	0.81	0.73	0.55	0.30	0.06	-0.13	-0.18	-0.18	-0.18	-0.17	-0.17	-0.17
APR/AVR	-0.16	-0.16	-0.16	-0.15	-0.15	-0.09	0.09	0.36	0.64	0.89	1.07	1.14	1.14	1.04	0.85	0.60	0.32	0.03	-0.16	-0.20	-0.19	-0.18	-0.18	-0.17
MAY/MAI	-0.18	-0.17	-0.17	-0.17	-0.13	0.01	0.27	0.60	0.93	1.20	1.37	1.40	1.35	1.26	1.04	0.80	0.50	0.20	-0.05	-0.19	-0.21	-0.20	-0.19	-0.18
JUN/JUIN	-0.20	-0.19	-0.19	-0.18	-0.12	0.09	0.40	0.76	1.09	1.36	1.54	1.60	1.58	1.41	1.21	0.92	0.64	0.32	0.02	-0.18	-0.23	-0.22	-0.22	-0.21
JUL/JUIL	-0.19	-0.18	-0.18	-0.17	-0.12	0.06	0.37	0.72	1.04	1.30	1.44	1.58	1.53	1.41	1.18	0.88	0.59	0.27	-0.02	-0.19	-0.22	-0.21	-0.20	-0.19
AUG/AOÛT	-0.17	-0.16	-0.16	-0.16	-0.15	-0.05	0.18	0.49	0.81	1.12	1.34	1.42	1.36	1.20	0.98	0.70	0.39	0.08	-0.14	-0.20	-0.18	-0.18	-0.18	-0.17
SEP/SEPT	-0.17	-0.17	-0.16	-0.16	-0.16	-0.15	-0.03	0.24	0.55	0.83	1.00	1.10	1.08	0.96	0.75	0.46	0.14	-0.12	-0.21	-0.20	-0.20	-0.19	-0.18	-0.18
OCT/OCT	-0.18	-0.18	-0.18	-0.17	-0.17	-0.17	-0.15	-0.03	0.21	0.45	0.63	0.72	0.71	0.60	0.39	0.14	-0.09	-0.20	-0.20	-0.20	-0.20	-0.19	-0.18	-0.18
NOV/NOV	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.13	-0.03	0.13	0.26	0.33	0.33	0.24	0.10	-0.07	-0.18	-0.18	-0.18	-0.17	-0.17	-0.17	-0.16	-0.16
DEC/DÉC	-0.14	-0.14	-0.14	-0.13	-0.13	-0.13	-0.13	-0.12	-0.08	0.01	0.09	0.13	0.13	0.08	-0.01	-0.11	-0.15	-0.15	-0.15	-0.14	-0.14	-0.14	-0.13	-0.14

MEAN DAILY NET RADIATION [illegible]
MOYENNE QUOTIDIENNE DU BILAN DU RAYONNEMENT SUR UNE SURFACE HORIZONTALE (RF-4)

	JAN JAN	FEB FEV	MAR MARS	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOUT	SEP SEPT	OCT OCT	NOV NOV	DEC DEC
BRITISH COLUMBIA **COLOMBIE-BRITANNIQUE**												
SUMMERLAND CDA												
Mean Moyenne	-1.18	0.32	3.33	6.33	8.14	8.82	8.53	6.41	4.15	1.23	0.41	1.10
Standard Deviation Ecart Type	0.28	0.72	0.66	0.56	0.79	0.48	0.48	0.67	0.68	0.31	0.29	0.62
YUKON TERRITORY **YUKON**												
WHITEHORSE A												
Mean Moyenne	-1.10	-1.48	-1.27	3.87	8.47	9.52	8.51	6.31	2.63	-0.60	-1.64	1.16
Standard Deviation Ecart Type	0.23	0.52	0.37	1.95	0.51	0.76	0.47	0.84	0.32	0.23	0.74	0.47
NORTHWEST TERRITORIES **TERRITOIRES DU NORD-OUEST**												
ALERT												
Mean Moyenne	-1.04	-1.37	-1.21	-1.38	-0.01	5.73	10.59	3.83	-1.26	-1.71	1.45	1.33
Standard Deviation Ecart Type	0.58	0.54	0.32	0.83	1.22	1.91	1.12	0.86	0.55	0.43	0.64	0.62
BAKER LAKE												
Mean Moyenne	1.76	1.86	-1.55	-0.35	6.37	11.06	9.47	6.00	2.35	-1.05	-1.75	1.54
Standard Deviation Ecart Type	0.60	0.58	0.77	1.00	3.81	0.63	0.78	0.65	0.44	0.71	0.43	0.32
EUREKA												
Mean Moyenne	-1.53	-1.29	-1.72	-0.99	3.98	12.61	9.90	4.49	-1.07	-1.53	-1.64	1.46
Standard Deviation Ecart Type	0.52	0.54	0.37	0.94	2.80	1.50	0.89	0.66	0.44	0.35	0.22	0.33
FROBISHER BAY A												
Mean Moyenne	-2.02	-2.36	-1.08	0.74	8.50	11.59	9.35	6.51	2.85	-0.63	2.25	2.38
Standard Deviation Ecart Type	0.55	0.37	0.41	1.16	2.21	0.56	0.99	0.87	0.34	0.66	0.34	0.77
ISACHSEN												
Mean Moyenne	-1.21	-1.19	-1.19	0.21	6.07	13.52	10.26	5.44	0.29	-0.98	-1.36	-1.16
Standard Deviation Ecart Type	0.32	0.22	0.58	1.04	2.06	0.91	0.95	0.52	0.33	0.26	0.38	0.29
MOULD BAY A												
Mean Moyenne	-1.41	-1.23	-0.69	-0.20	1.27	9.21	10.28	5.29	0.55	-0.71	1.22	1.31
Standard Deviation Ecart Type	0.38	0.37	0.54	0.61	1.11	2.86	1.04	0.67	0.54	0.30	0.64	0.34
NORMAN WELLS A												
Mean Moyenne	-0.87	-0.98	-0.92	2.79	9.28	10.93	9.87	6.54	2.59	-0.29	1.05	0.63
Standard Deviation Ecart Type	0.56	0.33	0.44	1.43	0.85	0.47	1.01	0.68	0.49	0.41	0.22	0.34
RESOLUTE A												
Mean Moyenne	2.16	1.98	-1.84	-0.56	2.32	7.79	8.77	4.55	0.20	-1.67	2.09	-2.05
Standard Deviation Ecart Type	0.68	0.69	0.44	0.84	1.89	2.68	1.03	0.68	0.51	0.55	0.73	0.73
ALBERTA **ALBERTA**												
EDMONTON STONY PLAIN												
Mean Moyenne	1.89	1.19	0.85	6.47	9.08	10.48	10.50	8.16	4.24	0.74	1.12	1.38
Standard Deviation Ecart Type	0.61	0.62	1.72	1.13	0.70	0.69	0.55	0.73	0.48	0.35	0.42	0.36
LETHBRIDGE A												
Mean Moyenne	2.39	0.44	2.82	6.15	9.14	10.97	10.51	8.14	4.82	1.15	-1.27	1.99
Standard Deviation Ecart Type	0.41	0.61	0.54	1.30	0.95	1.45	1.47	1.15	0.82	0.55	0.56	0.59

APPENDIX B3

ENERGY COSTS AND PROJECTIONS

In order to do a benefit-cost analysis for this study an estimate of future residential natural gas prices was needed. It was decided that the best source to use would be the updated Energy mines and Resources report issued in June of 1982. National Energy Program Update 82, Supplementary Information on Canadian Energy Supply/Demand Outlook 1981-2000. The following table lists the future natural gas prices as used in this study. These prices include service charges and franchize fees and reflect the price paid by the consumer.

The computer program required information for the standard electrical base load in the City of Lethbridge. Average electrical energy consumption is 6480 KWH per year, per household.

The average residential natural gas consumption for Lethbridge is 184 gigajoules per year. Of this amount 33 gigajoules are for domestic hot water heating, and 151 gigajoules are for space heating.

The new 100 square meter model home built to Alberta Building Code standards required a separate analysis to determine its energy consumption for space heating. Fourteen Lethbridge homes in this size and style were analyzed to determine the average energy consumption. This figure was then compared to the computer analysis of the 100 square meter home. The variation between the average actual consumption (113 gigajoules) and the computer analysis (124 gigajoules) was considered to be insignificant for the purposes of this study.

FUTURE RESIDENTIAL NATURAL GAS PRICES

FOR THE PROVINCE OF ALBERTA

YEAR	PRICE PER GIGAJOULE (Including Service Charges and Fees)
1982	$ 3.45
1983	$ 3.68
1984	$ 3.94
1985	$ 4.25
1986	$ 4.68
1987	$ 5.19
1988	$ 5.70
1989	$ 6.22
1990	$ 6.73
1991	$ 7.27
1992	$ 7.89
1993	$ 8.59
1994	$ 9.36
1995	$10.21
1996	$11.12
1997	$12.13
1998	$13.22
1999	$14.41
2000	$15.70
2001	$17.12

1. Source: National Energy Program Update 82, Supplementary Information on Canadian Energy Supply/Demand Outlook 1981/2000, Energy, Mines and Resources, June 1982.

APPENDIX B4

LETHBRIDGE CONTRACTOR SURVEY

CONTRACTOR INTERVIEWS

A telephone survey of 14 Lethbridge residential contractors was conducted. The following questions were asked. The results are tabulated in the following table.

Questionnaire

1) How many single family residences does your company build per year?

2) What size and style represents a typical new construction?

3) What typical size and price range home does your company build?

4) Is there an increased demand for better energy efficiency from new home buyers?

5) To what energy standards does your firm currently build?

   a) Alberta building code?

   b) Other?

R value walls
R value ceiling
R value basement
sliding windows
casement/awning windows
triple glazed windows
vapor barrier thickness
vapor barrier caulked

electronic ignition furnace
night set back thermostat
mechanical ventilation
heat exchanger
passive solar design

6) What is your firms retail price per square foot for a standard home?

7) Have any problems arisen from improving energy performance?

8) What is a typical energy cost per year for your newly constructed homes?

9) Does your firm do significant renovation activity?

10) At this point in time, would the market be prepared to pay more (5%) for increased energy performance (60%)?

Questionnaire Summary

Current Construction Practices in Lethbridge

1) The number of single family housing starts ranged from 2 to 40. The average for all builders interviewed was 11.3.

2) Contractors suggest that the standard new Lethbridge home is a 1000-1050 square foot split entry or bungalow style.

3) The majority of contractors interviewed currently build in the 1000 foot range at a price up to the Alberta mortgage loan program of $78,000.00.

4) 9 of 14 contractors perceive an increased interest in energy efficiency.

5) 9 of 14 contractors have increased at least one energy feature beyond the Alberta Building Code minimum standard.

- 9 contractors have increased wall insulation levels
- 5 contractors have increased basement insulation levels (minimally)
- 13 of 14 contractors use higher quality casement type windows
- 3 contractors have increased the quality of the air vapor barrier
- 1 contractor has increased all energy related standards

6) The average retail price reported is $53.00 per square foot. excluding land.

7) 2 contractors acknowledged problems related to increasing energy performance, both educational problems and not technical problems.

8) 2 contractors estimated yearly energy costs for space heating new 1000 square foot homes to be $130.00 per month and $80/month. None of the other contractors had any idea of energy costs.

9) 2 of the contractors interviewed are involved in rennovation activity.

10) 6 of 14 contractors said the market might now be interested in paying an increased capital cost for increased energy performance.

General Conclusions

The 'standard' Lethbridge home being constructed is the 1000-1050 square foot split entry or bungalow style. (This conforms to the Canadian Energy Reserach Institutes findings which state that the typical Canadian home is a 100 square meter bungalow).

Because of the economic climate, most construction activity is currently in the 1000 square foot range with prices limited to the level of mortgage available through the Alberta government mortgage assistance program.

This standard size house (100 square meters) will be utilized as the model home through which to compare energy performance and incremental costs for various conservation strategies.

Conservation Activity

There is an emerging demand for better energy performance, however this demand is in its infancy and only 64% of the contractors interviewed have responded, other than one contractor who specialized in low energy construction, increased energy standards have been limited to thicker above grade wall insluation and occasionally increased basement insulation.

Contractors have generally not increased air tightness through installation of a thicker, caulked air vapor barrier, although virtually all contractors utilize casement/awning style windows which decrease air leakage. None of the contractors, other than the energy conservation specialist, are installing improved efficiency furnaces (electric ignition) or night set back thermostats, unless specially requested by the customer. Other than the specialist builder, none of the contractors have considered passive solar design or lot orientation.

CITY OF LETHBRIDGE
NEW HOUSING STARTS AND RENOVATION ACTIVITY 1962 - 1981

YEAR	NEW HOUSE STARTS	RENOVATIONS AND ADDITIONS
1962	260	379
1963	184	341
1964	196	351
1965	131	346
1966	80	320
1967	261	327
1968	261	327
1969	201	336
1970	201	336
1971	305	319
1972	305	319
1973	443	375
1974	421	393
1975	522	492
1976	555	609
1977	441	674
1978	610	541
1979	224	562
1980	329	600
1981	487	591

* As recorded by the City building permit office.

CONTRACTOR QUESTIONS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. NO. HOMES	15	5	2	10	12	20	5	8	12	2	4	14	10	40
2. AV: LETHBRIDGE	1000 SP	1000 BU	1000 BU	----	1050 SP	1050 SP	1050	1000 SP	1000 SP	-----	1050 SP	1050 SP	1050 SP	1000 SP
3. CONTRACTOR SIZE & PRICE	90-95 1000 B's	1000	80-90	----	1050/76-78	1250/130,	1700/150,	1000 78,	900 74,	1500 125,	1150 80,	1100 85,	1150 85,	1000 78,
4. INCREASED DEMAND	NO	NO	YES	NO	NO	YES	YES	NO	NO	YES	YES	YES	YES	YES
5. CODE	YES	NO	NO	YES	NO	NO	YES	YES	NO	NO	YES	NO	NO	NO
R-WALL	12	20	20	12	17	20	12	12	48	20	12	20	20	17
R-CEIL	34	34	34	34	34	34	34	34	50	34	34	34	34	34
R-BASE	½ @ R8	½R20/½R12	½ @ R8	½ @ R8	½ @ R10	½ @ R8	½ @ R8	½ @ R8	30	½ @ R8	½ @ R8	R12	½ @ R8	½ @ R12
WINDOW - SLIDE					X									
- CASE	X	X	X	X		X	X	X	X	X	X	X	X	X
- TRIPLE									X					
VAP. BARR.	2 mil	2 mil	2 mil	2 mil	2 mil	2 mil	2 mil	2 mil	6 mil	2 mil	2 mil	4 mil	2 mil	2 mil
CAULKED?									YES					EXTRA CARE
ELEC. IGNIT.									YES					
NIGHT SET BACK									YES					
MECH VENT									YES					
HEAT EXCHANGE									YES					
PASSIVE SOLAR									YES					
6. RETAIL COST	$60.		$55.		$51.50	$55.	$50.	$50.	$56.		$50.	$55.	$50.	
7. ENERGY PROBLEMS									MARKET EDUCATION					TRADE EDUCATION
8. ENERGY COST	DON'T KNOW	?	$130/mo.	?	?	$80/mo. in winter	?	?	?	?	?	?	?	?
9. RENOVATIONS	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	YES	NO
10. MARKET INTERESTED	NO	NO	YES	NO	YES	NO	YES	NO	YES		YES	YES	NO	NO

ENERGY CONSERVATION PLANNING
AN ANNOTATED BIBLIOGRAPHY

1. What Can Municipalities Do About Energy? Toronto: Buereau of Municipal Research, March 1978.

   Demonstrates that municipalities have an important role to play in promoting sound energy use. Examines four areas for municipal action: land use and transportation planning, building and site design requirements, development of local renewable energy sources, and public education and demonstration programs.

2. The National Energy Program 1980. Department of Energy, Mines and Resources, 1980.

   A discussion of the Canadian energy situation within the context of national energy policies and programs.

3. Energy and Urban Form. Chibuk, John, Ministry of State for Urban Affairs, 1977.

   Discuss energy in relation to density, urban settlement patterns, land use arrangements and other urban form factors.

4. Local Energy Initiatives in Canadian Urban Settlements. Gibson, Judity, CMHC, March 1979.

   An examination of energy related projects in communities across Canada, including 50 case studies. These include institutional conservation programs, municipal infrastructure projects, urban planning, building design and construction, public information and educational activities.

5. Case Book on Energy-Conserving Land Use Planning and Control. Lang, Reg and Armour, Audrey. Department of the Environment, 1981.

6. Analysis of the United States Experience in Modifying Land Use to Conserve Energy. Sewell, Derrick W.R., and Foster, Harold D. Department of the Environment, 1980.

   An analysis of the American experience in land use planning for energy conservation, with a view to determining its relevance to Canada. The study includes detailed case studies of two communitiies, Portland, Oregon and Lincoln, Nebraska, with particular attention to the reaction to change within the communities and an identification of interest groups involved.

7. Passive Solar Heating In Canada. Gough, Bruce D., Department of Energy, Mines and Resources, 1979.

   A discussion paper suggesting that passive solar heating already contributes approximately one-eighth of Canada's gross residential heating requirements, and that it can be developed so as to become an even more significant renewable resource.

8. Perspectives on Access to Solar Energy. Saxe, Dianne. Ontario Ministry of Energy, 1978.

   A working paper on legal aspects of the right to light and its potential impact on land use, in the Ontario context but of wider general interest.

9. Passive Solar Energy Builds A Brighter Energy Future. Ontario, Hydro.

A publication demonstration how an energy efficient passive solar home can save energy and money. Eight case studies identifying heating demand difference between low energy passive solar homes and conventional homes is included.

10. A Guide To Municipal Energy Savings. Energy, Mines and Resources, Canada, 1982.

A ten volume series indicating the wide range of conservation possibilities in municipal operations. Each section of this publication discusses a different aspect of an internal energy management program, with particular attention to municipally-owned and operated facilities and equipment. These different aspects include designing an energy management program; energy and urban planning, auditing municipal energy use; financial/analysis of conservation measures; saving energy in municipal buildings; saving energy in street lighting; saving energy in the vehicle fleet; energy and urban transportation and municipal energy savings-case studies.

11. Saving Energy By Way of Site Design. Ontario Ministry of Housing, April, 1981.

This report identifies the relationship between subdivision design and the conservation of energy. The report demonstrates that there are no significant costs associated with adopting site planning techniques to demonstrate this, the report compares six subdivision plans for the same site with regards to energy use efficiency.

12. Building Toward 2001 Procedures. Ministry of Municipal Affairs and Housing, November 1-4, 1981.

A series of proceedings regarding issues dealing with existing housing in the community, current and future housing trends, residential energy conservation and community redevelopment.

13. Subdivisions and Sun 3 Design Studies. Ontario, Ministry of Energy.

This report contains three separate studies prepared by M.M. Dillon Ltd; Henry Fliess and Partners, Architects; and John Hix, Architect and Planner for the Ontario Ministry of Energy. The three studies identify ways in which residential subdivisions can be planned to maximize passive solar heat gain in winter while preventing overheating in summer.

14. Energy Conservation In New Small Residential Buildings. Canada Mortgage and Housing Corporation, NHA 5417 81/06.

Publication intended to assist homeowners, builders and small construction companies to understand the requirements of the "Measures" that affect small residential buildings and to illustrate acceptable building practices which satisfy those requirements. In particular, it investigates insulation techniques, air tightness and ventilation, heating systems and lighting.

15. Measures For Energy Conservation In New Buildings. National Research Council of Canada, No. 16574.

A National Research Council of Canada publication listing comprehensive measures for energy conservation in new buildings.

The measures include specifications for building enclosures; heating, cooling and ventilating; service water heating; and electric lighting.

16. Source Book: Energy Conservation in Twenty Canadian Cities. Lang, Reg and Armour Audrey, Toronto, 1980.

Survey of energy conservation activities in Canada's twenty largest cities, carried out in preparation for the cities and energy conference held in Toronto.

17. Energy Conservation and The Municipal Planner. Reg Lang, Audrey Armour, February, 1980. Prepared for Energy, Mines and Resources, Canada.

A publication which attempts to increase the awareness of municipal planners that energy issues and energy conservation can be achieved through their actions and responsibilities. In addition, it highlights technique which can increase the capability of municipal planners to deal with energy problems. In all, 50 planning-related energy conservation measures have been identified and assessed for applicability.

18. Energy Management In Municipal Operations: A Framework For Action. ICMA Energy Mangement Project, October 1981, No. 8.

This handbook, intended for local administrators, presents a frame work that can be used to assess the readiness of a municipal organization to carry out energy management programs and to determine the applicability and transferability of energy management programs that have been implemented elsewhere. Furthermore, case studies are outlined identifying how local governments are dealing with energy supply and cost issues within municipal operations.

19. Energy Policy For The City: Better Services With Less Energy. Commissioner of Planning and Development, City of Toronto Planning Board zoning and official plan division.

This report lists a number of recommendations adopted by City Council of Toronto on June 11, 1979 regarding energy conservation. While the report highlights the energy crises we face as a large society, it describes direct municipal actions that can reduce the efforts of the crisis. It argues that our policies must be directed at reducing demand at opposed to trying to match supply with demand.

20. The Conservation Of Energy In Housing. Central Mortgage and Housing Corporation, NHA 5149, 1977.

An industry document providing guidelines to small architectural and engineering firms, developers, builders, provincial and municipal authorities and the general public. It covers the planning of individual dwellings and groups of dwellings from the point of view of orientation, the size of the building, landscaping and thermal efficiency. The main focus is on upgrading existing houses and on ways of saving energy in appliance use and in heating systems.

21. Site Planning Guidelines For Medium Density Housing. Ontario Ministry of Housing, January, 1980.

A government document listing guidelines to be used by medium sized and smaller communities which have either no planning staff or very limited resources; members of council; and planning boards to better assess proposals put forward by developers. Such areas as density and housing form, site planning, landscaping and roads and dainage are

investigated. It is emphasized that these are only guidelines for development and not regulations.

22. Energy Conservation Through Official Plans - A Guideline. Ministry of Municipal Affairs and Housing, February, 1981.

A government publication outlining the direct role municipalities have to play regarding efficient energy planning and management. The emphasis is on official plan policies, zoning restrictions, subdivision approvals and site plan control.

23. Energy Conservation In Land Use Planning. Greg Ross, City of Brampton Senior Policy Planner, February, 1979.

This report investigates why we should be planning for energy conservation; who should be planning; and what planning should concern itself with. Guidelines and case studies are provided for demonstration purposes as well as for evaluation. Appendices provide technical information including climatological factors, site planning requirements and architectural design.

24. The City of Brampton Solar Zoning By-Laws. Prepared by Greg Ross. June, 1979, Revised by Pamela Schwartzberg, September, 1981.

A description of solar zoning by-laws presently being applied in subdivision department in the City of Brampton, By-Laws 139-79 and 111-91. The purpose of these by-laws was to ensure exposure to direct sunlight of the full south face of the units between specified hours during the heating season. Consequently, the by-laws make provision for such factors as solar orientation; maximum height restrictions for buildings; shadow effects; and vegetation cover.

25. By-Law No. 180-79. The Corporation of the City of Brampton.

Amends the Brampton Solar By-Law 139-79.

26. By-Law No. 139-79. The Corporation of The City of Brampton.

By-Law No. 139-79 is a solar zoning by-law approved by the council of the City of Brampton. The by-law pertains to a residential subdivision plan for a 50 acre parcel of land located in the west half of Lot 13, Concession 1 E.H.S. in Brampton, Ontario. This by-law was approved by the Ombin A???, 1979. The by-law contains regulations regarding setbacks, height restrictions, building orientation, and density mix.

27. Passive Solar Heating In Canada A Discussion Paper. Report ER 79-6. Energy, Mines and Resources Canada. Prepared by Bruce D. Gough, B. Arch, For the Conservaton and Renewable Energy Branch.

This paper provides a first-round architectural, technical and economic background for the discussion and implementation of passive solar heating in Canada.

28. Energy Planning In A Conserver Society, The Future's Not What It Used To Be. Robert Crow, Peter Szegory-Maszak, Christopher Conway, February, 1978. Energy Probe.

Addresses a very fundamental question: What type of energy planning can best enable the people of Ontario to achieve a future which conforms to the social, environmental and economic values on which a just society is based? More specifically, it analyzes the effectiveness of present Ontario Energy Planning Practice, and suggests some of the

changes that are necessary to improve it. Finally, these changes are applied through an alternative energy policy for Ontario based on renewable energy resources and conservation policies.

29. Perspectives On Access To Sunlight. Ontario Ministry of Energy, September, 1980.

Addresses solar access and its relation to the rights attached thereto. The paper outlines the existing law regarding the right to access to sunlight. In this regard, the paper provides descriptions of several potential mechanisms for the protection of solar access in Ontario. Some legal options evaluated in compared include private agreements, the doctrine of ancient lights, restrictive-convenants, solar zoning and the certification of solar sites.

30. Protecting Solar Access For Residential Development - A Guide Book For Planning Officials. U.S. Department of Housing and Urban Development.

This is a manual which indicates to planners how to use conventional land use controls to protect solar access in new residential development for space heating and cooling and domestic hot water. Identifies how solar access can be protected using existing authority of the Police Power or by private agreements.

LETHBRIDGE
ENERGY EFFICIENT STRATEGY
FOR RESIDENTIAL LAND USE

QUESTIONNAIRE

TELEPHONE NO. _____
ADDRESS _____
AREA: W☐ S☐ E☐

1. Tenure/Sex ☐ Renter ☐ Owner ☐ Male ☐ Female

2. Type of House ☐ Single ☐ Two Unit Dwelling ☐ Multi

3. Approximately how much do you spend on? (for household)
_____ Gasoline per week
_____ Public Transit per week
_____ Gas (Natural) per month
_____ Electricity per month

4. How many people in your household travel to work? _____ Please List.

Distance to Work (Round Trip)	Mode of Transport					
	Car as Driver	Car as Passenger	Public Transit	Motor Cycle	Bicycle	Walk
1. _____ Miles	☐	☐	☐	☐	☐	☐
2. _____ Miles	☐	☐	☐	☐	☐	☐
3. _____ Miles	☐	☐	☐	☐	☐	☐
4. _____ Miles	☐	☐	☐	☐	☐	☐

5. Do you think energy saving is important?
For transportation ☐YES ☐NO Why _____
In the home ☐YES ☐NO Why _____

6. Have you taken measures to reduce energy costs?
For transportation ☐YES ☐NO
In the home ☐YES ☐NO

7. If "YES", what measures have you taken?

Transportation (ie: smaller car, public transit, car pool)	Home (ie: insulation, air tightness, turn down thermostat)
_____	_____
_____	_____
_____	_____

8. If "NO", are you considering taking any energy conservation measures?
☐YES ☐NO

If so, what?

Transportation	Home
_____	_____
_____	_____
_____	_____

continued on reverse

9. If you are not considering taking conservation measures, why not?

10. Are you considering

Buying a new home?	☐ YES	☐ NO
Renovating your home?	☐ YES	☐ NO

11. Will energy costs be a factor in your selection?

☐ YES ☐ NO

12. How much extra would you be prepared to pay for a new home if you could save 60% every year on your heating bills?

☐ NO EXTRA

_____ DOLLARS

13. How much extra would you be prepared to pay on a home renovation if you could save 60% every year on your heating bills?

☐ NO EXTRA

_____ DOLLARS

14. Would finding a location close to work be an important factor if you were considering moving to a new house?

☐ YES Why _____

☐ NO Why _____

15. Do you think energy efficient housing looks unusual?

☐ YES
☐ NO

16. Would you like to see more housing closer to the City Centre?

☐ YES Why _____

☐ NO Why _____

17. Would you like to see smaller lots if it could reduce cost and lower taxes?

☐ YES Why _____

☐ NO Why _____